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Women Political Leaders as Agents of Environmental Change[*]

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Abstract

This paper explores how female political leaders impact environmental outcomes and climate change policy actions using data from mixed-gender mayoral races in Brazil. Using a Regression Discontinuity design we find that, compared to male mayors, female mayors significantly reduce greenhouse gas emissions. This effect is driven by a reduction in emissions intensity (CO2e/GDP) in the Land Use sector, without changes in municipal economic activity. Part of the reduction in emissions in the Land Use sector is attributable to a decline in deforestation. We examine potential mechanisms that could explain the positive environmental impact of narrowly electing a female mayor over a male counterpart and find that in Amazon municipalities, female elected mayors allocate more space to the environment in their government proposals and are more likely to invest in environmental initiatives. Differences in the enforcement of environmental regulations do not explain the results.

JEL Classification: J16, D72, Q54, Q56, Q58.
Keywords: gender, climate change, mayoral elections, Amazon, Brazil, Latin America.

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1 Introduction

Climate change is a pressing global concern that requires adequate and timely policies. Rising greenhouse gas emissions are rapidly increasing average global temperatures and altering rainfall patterns. These environmental changes have significant social and economic implications, including job losses, reduced productivity and hours of work, deficient development of foundational cognitive skills, changes in migration patterns, and increased poverty (e.g., Graff Zivin and Neidell, 2014; Jafino et al., 2020; Saget et al., 2020; Salemi, 2021; Pazos et al., 2024).

The climate crisis intersects with gender in important ways. First, political leadership plays a vital role in addressing climate change, and previous research shows that a leader's gender can influence policy decisions (Chattopadhyay and Duflo, 2004). Women leaders tend to promote better social outcomes, including increased spending and better health and education, reduced gender-based violence, lower levels of corruption, improved institutional quality, and higher rates of economic growth (Dollar et al., 2001; Jayasuriya and Burke, 2013; Bhalotra and Clots-Figueras, 2014; Bruce et al., 2022; Delaporte and Pino, 2022; Bochenkova et al., 2023). Second, studies indicate that perceptions of climate change differ by sex, with women generally exhibiting more awareness and concern than men (Ergas and York, 2012; Dechezleprêtre et al., 2022). These differences are often attributed to women's traditional roles as caregivers, subsistence food producers, and water and fuelwood collectors, as well as gender differences in values such as cooperation and attentiveness (Ergas and York, 2012). Given these patterns, we expect female leaders to adopt distinct environmental approaches compared to male leaders. Furthermore, since climate change exacerbates existing gender inequalities—disproportionately affecting women and girls through resource scarcity, increased risks of violence during crises like droughts, and higher likelihood of displacement during climate disasters (Habtezion, 2016; Marcos Morezuelas, 2021; Dehingia et al., 2024)—it is plausible to anticipate an additional effect if leaders are more likely to implement policy actions that address the needs of their own gender (Chattopadhyay and Duflo, 2004).

Therefore, we hypothesize that female political leaders might perform better than men in addressing climate change. We test this hypothesis using information on mixed-gender close mayoral electoral races in Brazilian municipalities. There are several reasons for focusing our analysis on Brazil. The country holds 60% of the Amazon rainforest, the largest tropical forest in the world, which plays a key role in global climate regulation. In addition, Brazil has more than 5 thousand municipalities with information on various outcomes related to climate change and on policy variables relevant to our analysis. Finally, Brazil is a highly decentralized country and its municipalities have decision-making power on environmental issues.

Identifying the causal effect of female political leaders on environmental and policy outcomes is challenging because of the presence of other factors, such as societal attitudes toward women, that may be correlated with both women winning an election and the outcome variables. To tackle this issue, we adopt a Regression Discontinuity (RD) design that compares outcomes in municipalities where a woman won an election by a narrow margin against a male candidate with municipalities where the winner was, by a narrow margin, a man (Lee et al., 2004). The intuition behind this comparison is that in close election races, the probability of winning is the same for women and men. Then, municipalities with a male mayor who won by a narrow margin are a good counterfactual for municipalities with female mayors who also won by a narrow margin. Previous studies have applied this approach in Brazil to analyze the impact of female leadership on other outcomes such as corruption (Brollo and Troiano, 2016), health outcomes (Bruce et al., 2022), and gender-based violence (Bochenkova et al., 2023; Delaporte and Pino, 2022).

We analyze outcome variables related to greenhouse gas emissions and deforestation at the municipal level. These two outcomes are related since deforestation is one of the main contributors to the levels of emissions. In fact, in Latin America, around 40% of the greenhouse gas emissions in 2019 originated from land use changes, such as converting forests to pastures or agricultural lands, and the burning of forest residues (Brassiolo et al., 2023). For greenhouse gas emissions, we consider the average annual emissions per municipality within each four-year mayoral term, both in tons of carbon dioxide equivalent (CO2e) and relative to municipal economic activity (CO2e/GDP). Additionally, we distinguish between total municipal emissions and sector-specific emissions. As for deforestation, we focus on changes in forest formations in each municipality over the four-year term of the mayors's mandates, measured as a percentage of the municipal forest cover. We conduct our analysis for all Brazilian municipalities with close mixed-gender elections and the subsamples of municipalities with vegetation typical of the Amazon biome (Amazon municipalities) and those without it (non-Amazon municipalities).

Additionally, we innovate by analyzing the mechanisms behind the impacts of having a woman elected as a mayor on climate change-related outcomes. These potential mechanisms include the importance assigned to the environment in elected mayors' government proposals, public spending and institutions devoted to environmental protection in each municipality, and enforcement of environmental regulations. For the first mechanism we consider the percentage of words in a candidate's government proposal that are related to the environment. For the second set of mechanisms we define three outcome variables: an indicator of whether the municipality has established an environmental council, a second capturing whether the municipality incurred any environmental expenditures during each mayoral term, and a measure of the percentage of the municipal budget allocated to environmental expenditures over each term. Enforcement efforts are measured as the number of fines issued due to deforestation infractions detected in each municipality.

Our findings show that there is a positive impact on environmental outcomes at the municipal level when a woman wins a mayoral election against a man by a narrow margin and these effects are driven by municipalities with Amazon biome. In these municipalities, when a woman wins the election, annual greenhouse gas emissions decrease by 1,510 thousand tons of CO2e per municipality. This effect alone represents 23% of the average annual emissions of all municipalities within the Amazon biome and 6.4% of Brazil's nationwide average. Importantly, this reduction is due to a reduction in emissions intensity (CO2e/GDP) in the Land Use sector, without changes in municipal economic activity. Part of the reduction on emissions in the Land Use sector is attributable to a decline in deforestation. Female-led municipalities in the Amazon experience a reduction in deforestation, with a 3 percentage-point decrease in the loss of forest formations relative to municipal forest cover. This represents a 32% reduction compared to deforestation levels in the comparison municipalities.

These results are robust to changes in key parameters of our RD specification and to adjustments in the estimation sample, including changes in the bandwidth choice, kernel, and polynomial order, and excluding observations near the cutoff. We also show that the main results are not driven by the subset of municipalities that were part of the List of Priority Municipalities (LPM), a federal initiative that sought to reduce deforestation rates establishing targets of reduction for municipalities with the highest deforestation rates and sanctions in case of non-compliance.

A potential challenge in identifying the effects of the gender of the winning politician is that female candidates in close elections may possess compensating attributes, such as higher ability, to overcome gender biases of the voters (Marshall, 2024). These attributes could influence outcomes, causing our estimates to reflect a compound effect of bundled treatment rather than an isolated gender effect. In our analysis, most predetermined characteristics are balanced near the cutoff, except that female mayors are more educated. While higher education could influence our results if it correlates with environmentally protective policies, we present evidence showing that education does not significantly affect our key outcomes. Additionally, we show that voters probably did not prioritize environmental issues when voting, making compensatory differentials targeting such concerns unlikely and not biasing our results. However, unobservable factors, such as non-cognitive skills, political experience, or networks, can act as compensating differentials that help women win elections and implement environmental policies. Therefore, we acknowledge that our estimates may capture both gender effects and these additional influences.

The analysis of mechanisms indicates that female leaders respond differently to climate change in terms of public policy, especially in Amazon municipalities. In this area, policy proposals from female elected mayors contain 0.16 percentage points more environmental-related terms compared to those from male elected mayors, which represents a 50% increase relative to the baseline. Additionally, when a woman wins the election, the likelihood of these municipalities investing in environmental initiatives increases by 13 percentage points. The evidence also suggests differences in the enforcement of environmental regulations do not explain our main results.

This paper provides the first causal evidence that electing women as municipal mayors reduces both greenhouse gas emissions and deforestation, using data from Brazil–a country central to global climate mitigation. While a growing number of cross-country studies have linked womens political empowerment to improved environmental outcomes–lower CO_2 emissions (Zhike and Deng, 2019; Ergas and York, 2012), reduced climate vulnerability (Asongu et al., 2022), higher treaty ratification rates (Norgaard and York, 2005), stricter climate policies (Mavisakalyan and Tarverdi, 2019), and greater renewable energy production and consumption (Bansal and D'Agosti, 2023; Slamon, 2023)–causal analyses remain scarce. Two exceptions are Beraldi and Fosco (2025), who show that more female councilors in Italy cut air pollution, and Jagnani and Mahadevan (2021), who find that electing women legislators in India reduces crop-fire incidents. Building on this limited quasi-experimental evidence, our paper studies how and why electing women as mayors, in a key developing country such as Brazil, can improve environmental outcomes. We document substantial emissions and deforestation declines under female leadership and trace potential channels through which these gains occur. In doing so, we advance three literatures: (i) the impacts of female political leadership, which has been shown to boost health, education, institutional quality, and to curb corruption and gender violence; (ii) the political economy of environmental degradation, where deforestation at the municipal level reflects mayors backgrounds and interests (Bragança and Dahis, 2022; Katovich and Moffette, 2024; Dahis et al., 2023); and (iii) environmental justice, by demonstrating that women in power enact greener policies that especially benefit those who bear the greatest climate burden.

The remainder of the paper is organized as follows. Section 2 delves into the institutional context, focusing on Brazil's federal organization and delineating the powers vested in municipal governments, particularly their authority to define climate change policies and access financing mechanisms. Section 3 describes the data sources, the working sample and variables of interest, while Section 4 outlines the empirical strategy. Section 5 presents the main results, including robustness checks, and Section 6 explores the mechanisms at play. Finally, Section 7 draws the main conclusions.

2 Institutional context

Municipalities across Brazil exhibit a high degree of decentralization and autonomy. Local governments collect taxes, promulgate laws, decide how to use federal transfers, and provide several public goods, including education, health, and infrastructure (Souza, 2002; Delaporte and Pino, 2022). Regarding environmental protection, the Federal Constitution of 1988 implemented a multi-tiered management system. Under this arrangement, protecting the environment, combating pollution, and preserving forests, fauna and flora are a shared responsibility between the federal government, states, and municipalities. Within this decentralized system, municipalities can complement federal and state regulations and legislate on environmental issues of local interest–i.e., areas in which there is a predominance of municipal interest over state and federal interest (Neves and Whately, 2016). Moreover, in some municipalities–mainly those that are larger and more economically dynamic–the decentralization of environmental management was strengthened with the creation of municipal environmental agencies starting in the 1990s (Neves, 2016).[1]

There are numerous examples of municipality-level programs and initiatives aimed at addressing climate change-related challenges (Sills et al., 2020). For instance, the municipality of Lucas do Rio Verde in the state of Mato Grosso implemented a program focused on monitoring local land use and land cover changes. Similarly, the municipality of Paragominas in Pará state established collective arrangements with local farmers' and rural producers' unions, as well as external non-governmental organizations, to combat deforestation. Municipal initiatives are also oriented to the reduction of greenhouse gas emissions. For instance, the municipalities of Belo Horizonte and São Paulo have implemented programs to increase population density along main public transport hubs and have reduced the parking spaces in buildings located close to these hubs. Other examples relate to policies oriented to land use changes and forestry. On this line, several municipalities are encouraging the maintenance and expansion of green areas helping to increase the carbon storage capacity, cool temperatures, reduce heat islands, improve air quality, as well as enabling a change in society's perception of the importance of green areas (SEEG, 2021).

In certain instances, municipal involvement has been prompted by federal and state laws. This was the case with the List of Priority Municipalities (LPM) implemented at the federal level by the Ministry of Environment in 2008. The LPM is a sort of blacklist aimed at identifying municipalities with the highest rates of deforestation and penalizing those failing to meet the targets for reducing deforestation and registering property boundaries for deforestation monitoring (Sills et al., 2020). Local leadership played a pivotal role in getting municipalities off the list through coordination with local agents and NGOs (dos Santos Massoca and Brondízio, 2022). At the state level, Pará established the Green Municipality Program as a response to the federal LPM with the goal of enhancing the capacity of local governments to respond to the federal LPM. This program engaged municipal governments in the enforcement of federal forest regulations.

Regardless of the presence of federal or state regulations triggering municipal engagement in climate change policy actions, the extent of local involvement depends on various factors. First, local governance capacity might be weak, limiting the possibilities of influencing climate-change related actions (Neves and Whately, 2016; Sills et al., 2020). Second, the implementation of policies might be limited by a municipality effective fiscal and spending capacity (Neves, 2016). To date, existing sources of funding are municipal treasuries and environmental funds instituted at the three governmental levels (i.e., municipalities, states, and federal government), and other mechanisms such as the ecological VAT. Spending on climate change-related policies and on environmental policies more generally is discretionary and decided in each fiscal period when the budget is voted upon by municipal councils (Rodrigues Afonso and Amorim Araujo, 2006). This feature means that it is possible to observe changes in municipal spending on climate-change

[1] Environmental agencies or councils consist of expert professionals who offer guidance and recommendations to local governments on matters related to climate change and environmental issues.

related policies once a female mayor is elected. Third, if the local government is supported by powerful interest groups, such as local agricultural producers, this might limit the political convenience of implementing climate-change related policies (Bragança and Dahis, 2022). Finally, and as we argue in this paper, differences in preferences among municipal mayors may also influence the implementation of such policies. Specifically, we expect female mayors to be more aware and concerned about the social and economic consequences of climate change than male mayors.

3 Data

3.1 Municipal elections and sample definition

The data on municipal mayoral elections and candidates' characteristics are publicly available from the *Tribunal Superior Eleitoral*'s open data portal. We analyze four municipal mandates corresponding to the 2005-2008, 2009-2012, 2013-2016, and 2017-2020 mayoral terms. Elections occur the year before each mandate begins (2004, 2008, 2012, and 2016). For each election, we have information on candidates' vote shares and characteristics such as gender, education, age, marital status, and political party. The unit of analysis is a municipality in a specific electoral round and its associated term in office, encompassing data from the election and the subsequent mandate. We refer to these as municipality-term observations for simplicity.

Table 1 details our sample definition. We proceed by selecting municipalities where elections were resolved in the first round.[2] These represent 93.4% of all the municipality-term observations within our period of analysis. Then, we identify municipalities with mixed-gender elections defined as elections where the two candidates with the larger share of votes are a man and a woman. As we will see later, we use the information on the share of votes to calculate the running variable in our RD design, which is the vote share of the female candidate minus the vote share of the male candidate. This sample includes 3,889 municipality-term observations: 736 from the 2004 round, 930 from the 2008 round, 1,124 from the 2012 round, and 1,099 from the 2016 round. Overall, the municipalities with mixed-gender elections acount 17.5% of all municipality-term observations and 18.7% of those where the elections were resolved in the first round. Figure A.1 in the Appendix shows the geographical distribution of the mixed-gender elections in Brazil for each round. These elections seem to be evenly distributed across regions. However, as we will show below, municipalities with mixed-gender elections and their mayors exhibit differences in certain variables compared to others, which calls for caution when considering the possibility of extrapolating our results to the entire country.

[2]In Brazil, mayors are elected in a single round in municipalities with up to 200,000 voters, where the candidate with the most votes wins. In larger municipalities, an absolute majority (over 50% of valid votes) is required; otherwise, a second round is held between the top two candidates. We select municipalities where elections are resolved in the first round, requiring no rerun, and where there were no irregularities.

Table 1: Municipalities with mayoral elections by round

	2004	2008	2012	2016	Total
Total mayoral elections	5,561	5,562	5,568	5,564	22,255
Selected mayoral elections	5,208	5,213	5,220	5,141	20,782
% Selected elections	93.6%	93.7%	93.7%	92.4%	93.4%
Mixed-gender mayoral elections	736	930	1,124	1,099	3,889
% Mixed-gender elections	14.1%	17.8%	21.5%	21.4%	18.7%

Notes: Total mayoral elections are the total number of mayoral elections in each round. Selected mayoral elections refer to the group of municipalities where elections were resolved in the first round, requiring no rerun, and there were no irregularities. Mayoral mixed-gender elections are defined as elections where the two candidates with the largest share of votes are a man and a woman.

3.2 Greenhouse gas emissions

Data on greenhouse gas emissions come from the Greenhouse Gas Emissions and Removals Estimation System (SEEG), an initiative of the Brazilian Climate Observatory. SEEG estimates annual emissions for each municipality from five sectors: Agriculture, Industrial Processes, Energy, Land Use and Forestry, and Waste.[3]

Greenhouse gas emissions in the Land Use and Forestry sector primarily stem from annual land use changes recorded by the MapBiomas project. For instance, the conversion of forests to pastures or agricultural lands is a change in the use of land that releases carbon dioxide (CO2). Another example is the burning of forest residues that emits CO2 as well as other greenhouse gases such as nitrous oxide (N2O) and methane (CH4). The Land Use sector also plays a key role in CO2 removal: managed forests and protected areas (like Conservation Units and Indigenous Lands) contribute to CO2 reductions through photosynthesis, although mature forests typically exhibit limited changes in their carbon stock. Secondary vegetation, such as regenerating forests and grasslands, also plays a role in CO2 removal, while land use changes that increase carbon stocks—such as converting pastures to planted forests—lead to CO2 sequestration.

Regarding the other sectors, Agriculture includes emissions from crop production and livestock farming; emissions in the Energy sector arise from fuel combustion, which releases chemical energy as heat, and fugitive emissions from coal, petroleum, and natural

[3]To our purposes, it is important to emphasize that these data specifically account for greenhouse gas emissions generated within each municipality. This is because SEEG estimates emissions based on the activities conducted within each sector and municipality. This ensures that the measurements accurately reflect the emissions produced locally and do not include emissions from neighboring areas—e.g., emissions traveling through the air to adjacent municipalities. SEEG estimates of greenhouse gas emission and absorption are generated following the Brazilian Emission and Absorption Inventories of Anthropogenic Greenhouse Gases (BI), developed by the Ministry of Science, Technology, and Innovation (MCTI). The BI are based on the guidelines of the Intergovernmental Panel on Climate Change (IPCC) which are embedded with data obtained from government reports, institutes, research centers, sectoral entities, and non-governmental organizations. The SEEG methodology was published in the scientific journal Scientific Data, by the Nature group, in 2018. For more details, visit https://seeg.eco.br/metodologia/.

gas production processes; the Waste sector accounts for CO_2, CH_4, and N_2O emissions from urban solid waste, sludge, health service waste, incineration, open burning, and liquid effluent treatment; finally, even though industrial activities can produce emissions through fuel combustion, waste disposal, and chemical or physical material transformation processes, only the latter are categorized under the Industrial sector, while fuel combustion emissions are assigned to the Energy sector and waste disposal emissions to the Waste sector. Since 98% of the observations do not have information on emissions from the Industrial sector, we exclude it from the analysis.

Our outcome variables related to greenhouse gas emissions are defined as the average annual emissions for each four-year mayoral term. Emissions are quantified in tons of carbon dioxide equivalent (CO_2e), allowing for the comparison of different gases based on their global warming potential. We conduct the analysis focusing on emissions in tons of CO_2e, while also evaluating emissions intensity—i.e., emissions/GDP, where GDP stands for Gross Domestic Product—at the municipal level to account for the influence of economic activity. Our analysis includes both total emissions[4] and sector-specific emissions. In all cases, we focus on net emissions.

3.3 Deforestation

Data on land use and land use change at the municipal level come from the MapBiomas project, which classifies land use based on 30-meter resolution LANDSAT images. MapBiomas is an initiative of the Climate Observatory co-created and developed by a multi-institutional network involving universities, NGOs, and technology companies. MapBiomas identifies deforestation as a transition from natural vegetation to any form involving alteration due to human activity such as urban areas, agricultural lands, and pastures.

We use information on forest cover loss, as the literature on deforestation typically focuses on forest formations, which account for 70% of the total area covered by natural vegetation in municipalities within the Amazon biome. We refer to this as deforestation for simplicity. Our variable of interest is the total deforestation of forest formations in each municipality for each four-year mayoral term, measured as a percentage of the forest cover in each municipality during the baseline year, both measured in hectares. The baseline forest cover is defined as the total area of forest formations in the year prior to the start of each term.

3.4 Descriptive statistics

Table A.1 compares the characteristics of municipalities and mayors in our sample—i.e., municipalities with mixed-gender elections—to the rest of Brazilian municipalities and

[4]The total emissions variable is constructed by adding the emissions from all sectors except for the Industrial Processes, as the latter has a high incidence of missing values. If we incorporate the Industrial sector into the total emissions variable, the effects remain virtually unchanged. The results are available upon request.

mayors. Municipalities in our sample have a slightly larger area than the others. While they have similar GDP, the GDP per capita in our sample is lower, and the productive structure is more concentrated on public administration. In terms of population size, municipalities in our sample are comparable to the others but are slightly more rural, with a larger share of their population having low skills. Female labor force participation and employment rates are also lower in our sample, suggesting wider gender gaps.

There are also differences in the characteristics of the mayors between our sample and the rest of municipalities. By construction, in municipalities with mixed-gender elections, the share of female mayors is significantly higher—42% compared to just 2% in the other municipalities. Additionally, mayors in our sample tend to be slightly younger, less likely to be married, and more educated. As we will see later, this latter difference is closely linked to the higher share of female mayors in the mixed-gender elections sample. The distribution of mayors across the four main political parties—*Partido dos Trabalhadores* (PT), *Partido do Movimento Democrático Brasileiro* (PMDB), *Democratas* (DEM), and *Partido da Social Democracia Brasileira* (PSDB)—is similar between municipalities in our sample and the rest, although mayors in our sample are slightly more likely to belong to the small parties.[5,6] These differences between municipalities in our sample and the others highlight the need for caution when extrapolating our results to the broader context of Brazil.

Regarding our outcome variables, Table A.1 shows that in the mixed-gender elections sample, annual emissions average 229,047 tons of CO2e. The Agriculture sector accounts for the largest share (44% of total emissions), followed by Land Use (36%). In municipalities within the Amazon biome, average emissions increase 3.4 times, reaching 779,483 tons of CO2e per year. Notably, the table indicates no statistically significant differences between municipalities with mixed-gender elections and others, whether in terms of total emissions, emissions from the Land Use sector, or emissions specifically within the Amazon biome. Concerning deforestation, it amounts to 5% of the baseline forest cover per mayoral term, on average, for the municipalities in our sample. Focusing on the Amazon, the municipalities in our sample exhibit an average deforestation rate of

[5] PT (Workers' Party) is a center-left party with strong ties to labor movements and social programs; PMDB (Brazilian Democratic Movement Party, or just Brazilian Democratic Movement since 2017) is a centrist party known for its flexible alliances; DEM (Democrats) was a centre-right political party advocating for economic liberalism and conservative values; DEM merged with the far-right *Partido Social Liberal* (Social Liberal Party) to found the Brazil Union in 2021; and PSDB (Brazilian Social Democracy Party) is a center-right party focused on social democracy and market-oriented reforms. These four are the main political parties in Brazil. During our period of analysis, Brazil has been governed by PT presidents Luiz Inácio Lula da Silva (2003-2011) and Dilma Rousseff (2011-2016). Michel Temer from PMDB served from 2016 to 2018 following Rousseff's impeachment. Jair Bolsonaro was elected in 2018 with the Social Liberal Party and later joined the *Partido Liberal* (Liberal Party) during his presidency (2019-2022).

[6] When considering all candidates, not just the winners, the higher concentration in smaller parties is a common trend among female candidates, and this trend is even more pronounced in municipalities outside our sample. While the average number of candidates per election is similar across both samples (around 2.7), women account for 42% of candidates in our sample, 53% of whom belong to smaller parties. In contrast, women represent only 4% of candidates in other municipalities, with 62% of them affiliated with smaller parties.

10%, compared to 8% in the rest of the Amazon municipalities.

4 Empirical strategy

A key empirical challenge in identifying the effect of having a female mayor on policy outcomes is the potential correlation between municipality-specific factors and both the likelihood of a woman being elected as mayor and the policy outcomes. To control for these confounding factors, we adopt an RD design in mixed-gender close electoral races. This design will allow us to compare municipalities where a female candidate barely won an election against a male candidate with municipalities where the opposite occurred.

Based on the sample of mixed-gender mayoral elections in Brazil, we estimate the following equation:

$$Y_{ist} = \alpha + \beta \times FemaleMayor_{ist} + f(FemaleVoteMargin_{it}) + \gamma_t + \lambda_s + \epsilon_{ist}, \qquad (1)$$

where Y_{ist} represents the environmental outcomes or policy variables of municipality i in state s observed during the four-year mayoral term t. $FemaleMayor$ equals 1 if a woman won the mayoral race in the election held in the year prior to the start of term t in municipality i and state s. $FemaleVoteMargin_{ist}$ is the running variable in this RD design, and it is defined as the vote share of the female candidate minus the vote share of the male candidate. The polynomial function $f(FemaleVoteMargin_{ist})$ represents the fitted polynomials in the female vote margin on both sides of the threshold, which is estimated following Calonico et al. (2014).[7] In our main analysis, we use a first-degree polynomial and show in the robustness section that our findings hold for higher-order polynomials. ϵ_{ist} represents the error term. The baseline specification of Equation 1 includes mayoral term fixed effects (γ_t) and state fixed effects (λ_s). In other specifications we include additional controls to improve precision in our estimates (Calonico et al., 2019). These controls include predetermined municipality characteristics (population size and value added by sector), contemporaneous mayoral characteristics (age, level of education, marital status, and party of affiliation), and the value of the dependent variable in the year prior to the start of term t. We cluster standard errors at the municipal level.

β is the coefficient of interest. While we cannot guarantee that our strategy isolates the causal effect of the mayor's gender on the outcomes of interest (see Section 5.5), it does capture the causal effect of a combined treatment, i.e., the impact of a woman winning the election (Marshall, 2024), provided that the density of the running variable is continuous at the threshold and that predetermined characteristics are balanced. To show that near the cutoff, municipalities with a female mayor are similar to those with

[7] It is worth clarifying that the optimal bandwidth in our RD design does not define what constitutes a *close election*. Rather, it determines the range of observations used to fit the local polynomial for estimation (Calonico et al., 2014). Thus, our coefficient of interest is identified from elections with narrow margins (i.e., *close elections*), aided by a local polynomial estimated using observations slightly further from the zero-margin cutoff.

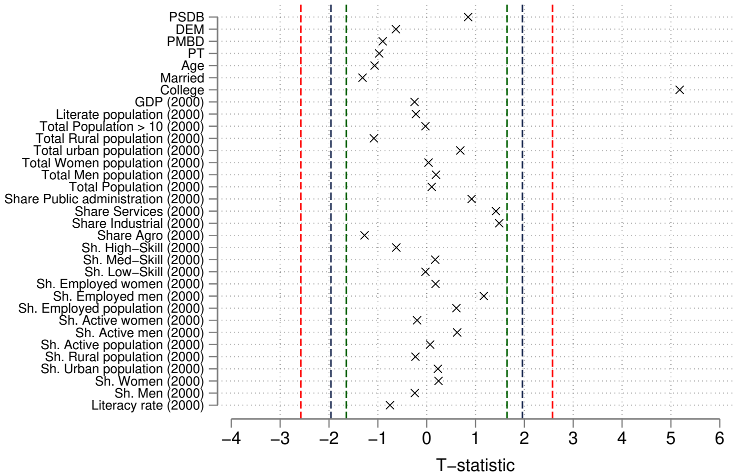
a male mayor in terms of observable characteristics, we estimate Equation 1 for a range of characteristics at both the mayor level—political party, education, age, marital status, among others—and municipal level—total population, female population, per capita GDP, literacy rate, among others. Figure 1a reports the t-statistics of β from Equation 1, where such characteristics are the outcome variables. We find that our sample is balanced in most predetermined characteristics, with the exception of the candidate's education. We complement these results with a graphical illustration of the RD effects for each pre-determined variable, providing additional evidence that they do not exhibit discrete jumps at the cutoff (see Figures A.2 and A.3 in the Appendix).[8] Additionally, in Figure 1b we conduct a similar analysis for the subsample of municipalities with vegetation typical of the Amazon biome (Amazon municipalities), confirming that the characteristics are also generally balanced within this subsample. This subsample is particularly relevant for our analysis, as Section 5 shows that the environmental effects of electing a woman are concentrated in the Amazon region.

Secondly, although unlikely in our context, we verify the absence of manipulation of the running variable in a local neighborhood near to the cutoff ($FemaleVoteMargin_{ist} = 0$). We run the manipulation test based on the density discontinuity developed in Cattaneo et al. (2018), and find a p-value of 0.6, i.e., we fail to reject the null hypothesis of no difference in the density of municipalities with a female mayor and with a male mayor at the cutoff. Figure A.4 in the Appendix graphically illustrates the continuity in the density test approach: the density estimates on both sides of the cutoff are very similar, and the confidence intervals overlap for both the entire sample of municipalities with mixed-gender elections and the subsample of municipalities in the Amazon region.

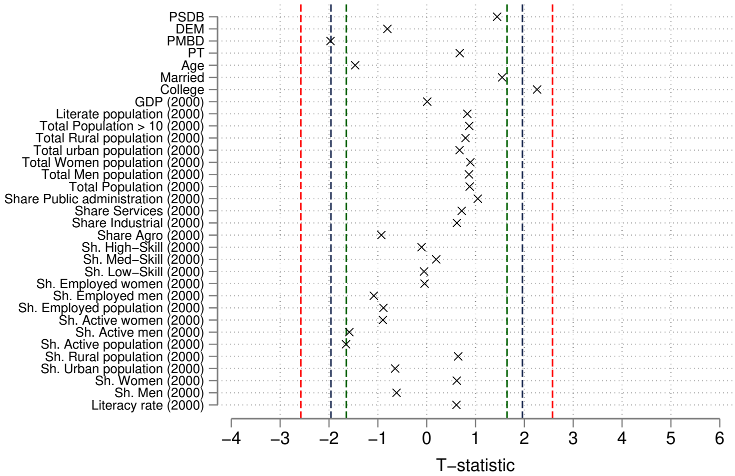
[8]Previous studies utilizing an RD design in mixed-gender close elections in Brazil have demonstrated the balance of predetermined municipal and mayoral characteristics at the threshold, supporting the validity of our identification strategy. Like our findings, these studies show that these characteristics are generally balanced, with the exception of education, where female mayors tend to be more educated than their male counterparts. For instance, see the work of Brollo and Troiano (2016) on corruption and Bochenkova et al. (2023) on violence against women.

Figure 1: Covariates balance around the threshold

(a) Total



(b) Amazon region



Notes: The figures show the t-statistics from our RD (Equation 1) using predetermined municipal and mayor characteristics as outcomes for all municipalities with mixed-gender elections (Panel a) and for the subsample of Amazon municipalities (Panel b). Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level. The red, blue and green lines indicate the 1%, 5% and 10% significance level thresholds respectively.

5 Main results

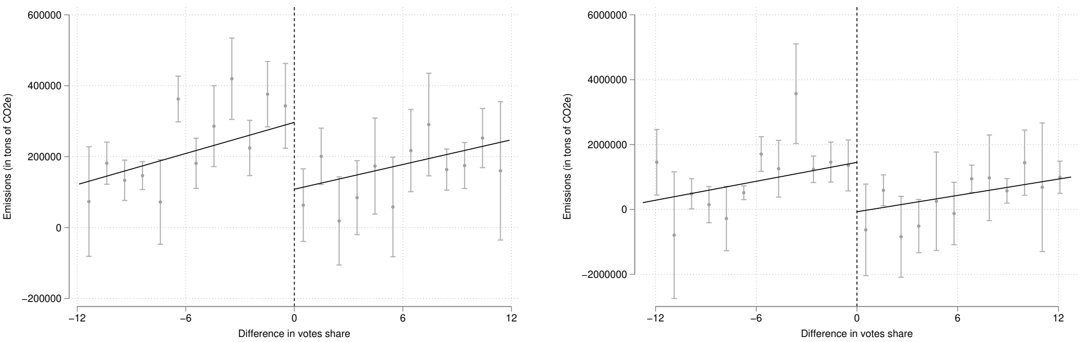
In this section we present the main results about the impact on environmental outcomes of women winning municipal elections in Brazil. Our analysis focuses on greenhouse gas emissions and deforestation, two key indicators that can capture efforts to mitigate climate change.

Figure 2 begins by providing preliminary evidence on the relationship between the margin of victory and greenhouse gas emissions. The horizontal axis measures the margin of victory in favor of a woman, defined as the difference between the percentage of votes received by the female candidate and the percentage of votes received by the male candidate in mixed-gender municipal elections. A positive margin of victory indicates a win for the woman. The figure shows a discontinuity in emissions at the municipal level depending on whether women or men won: in municipalities where a woman won—to the right of zero—, greenhouse gas emissions are lower compared to municipalities where a man won, both across the entire country (Figure 2a) and when focusing solely on municipalities within the Amazon biome (Figure 2b). The graphical evidence suggests an improvement in environmental outcomes at the municipal level when a woman wins the election.

Figure 2: Female mayor and emissions (in tons of CO_2e)

(a) All municipalities

(b) Amazon municipalities



Note: These figures graphically illustrate the effect of female mayors on total greenhouse gas emissions in municipalities with mixed-gender elections, both across the entire country (left panel) and within the Amazon region (right panel). Emissions are measured in tons of COe, averaged per year over each four-year mayoral term. The solid lines illustrate first-degree polynomials fitted to the running variable on either side of the threshold. Gray dots correspond to averages for bins of the running variable, with vertical lines showing the 90% confidence intervals for these averages.

In what follows, we report the formal estimates based on the RD design described in Section 4. Overall, these results validate the preliminary findings from Figure 2.

5.1 Effect on greenhouse gas emissions

Table 2 shows the RD estimates regarding greenhouse gas emissions in tons of CO_2e, calculated as the annual average over the four years of each mayoral term. Column 1 corresponds to the baseline model in Equation 1, which only includes controls for mayoral term and state fixed effects. This is our preferred specification. Columns 2 to 4 gradually introduce additional controls—municipality controls, mayor controls, and the outcome from the previous year. In particular, column 3 includes controls at the mayor's level—age, level of education, marital status, and party of affiliation. Notably, the results are highly robust across specifications, indicating that the effect we identify from a woman winning the election is not due to differences between female and male mayors in terms of education, political party, or other included observable characteristics. In what follows, we primarily focus on the baseline model in column 1 to describe our findings.

Panel A in the table reports a statistically significant reduction in annual CO2e emissions in municipalities with female mayors compared to those with male mayors. Specifically, in municipalities where women narrowly won the election, annual emissions are, on average, 219 thousand tons of CO2e lower than in municipalities where men won by a similar margin. This represents a 75% reduction in the average annual municipal emissions per mayoral term when a woman is elected.[9]

Table 2: Female mayor and emissions (in tons of CO2e)

	(1)	(2)	(3)	(4)
Panel A: Total				
Female mayor	-218,756**	-225,477**	-230,113**	-265,355**
	(101,193)	(101,179)	(101,512)	(104,064)
Mean outcome	291,668	291,668	291,668	291,668
Bandwidth	12.8	12.8	12.8	12.8
Observations	[1156, 1035]	[1156, 1035]	[1156, 1035]	[1156, 1035]
Panel B: Amazon region				
Female mayor	-1,509,865***	-1,348,315**	-1,098,764**	-1,428,845**
	(585,299)	(558,625)	(546,566)	(575,735)
Mean outcome	1,449,452	1,449,452	1,449,452	1,449,452
Bandwidth	12.8	12.8	12.8	12.8
Observations	[140, 125]	[140, 125]	[140, 125]	[140, 125]
Panel C: Non-amazon region				
Female mayor	-27,744	-36,305	-42,404	-44,069
	(37,958)	(37,936)	(41,676)	(40,598)
Mean outcome	184,980	184,980	184,980	184,980
Bandwidth	16.2	16.2	16.2	16.2
Observations	[1275, 1051]	[1275, 1051]	[1275, 1051]	[1275, 1051]
Year & State FE	Yes	Yes	Yes	Yes
Municipality controls	No	Yes	Yes	Yes
Mayor controls	No	No	Yes	Yes
Outcome t-1	No	No	No	Yes

Notes: The dependent variable is the average annual emissions in tons of CO2e over the four-year term in all municipalities with mixed-gender elections (Panel A), the subsample of Amazon municipalities (Panel B), and the subsample of non-Amazon municipalities (Panel C). Municipality controls include population size, GDP, and share of value added by sector (agriculture, industry, services, and public administration). Mayor controls are age, level of education, marital status and party of affiliation (PT, PSDB, DEM, PMDB). Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level in parentheses * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$.

Next, we re-estimate our RD model for two subsamples: municipalities with vegetation typical of the Amazon biome (Amazon municipalities) and those without (non-Amazon municipalities). Panels B and C of Table 2 report these results, confirming that the Amazon municipalities are driving the effect identified for the entire sample. When

[9] We compute the baseline mean outcome for electoral term t as the average annual CO2e emissions in the preceding term. This is specifically calculated for municipalities where men candidates won the election corresponding to term t, with the margin of victory falling within the optimal bandwidth.

a woman wins the election in Amazon municipalities, annual greenhouse gas emissions decrease by 1,510 thousand tons of CO2e per municipality. This effect is larger than that estimated for the total set of municipalities. In contrast, we find no evidence of effects on emissions in the non-Amazon municipalities.

The key takeaway from these results is the statistically significant and negative effect of female leadership on emissions, particularly in the Amazon region. However, the magnitude of the estimated impact should be interpreted with caution. As is often the case in this type of studies, estimated effects tend to be relatively large, reflecting local treatment effects around the threshold.[10] Indeed, in a robustness check accounting for potential outliers, our effect remains negative and statistically significant, although its magnitude is reduced by half (see Section 5.4).

That said, it is useful to illustrate the scale of these effects with some back-of-the-envelope calculations. If we focus on the 113 Amazon municipalities with mixed-gender elections, they collectively produce an average of 88 thousand tons of CO2e per year during the period under analysis.[11] Without the effect of female mayors in these municipalities, annual emissions would have reached 160 thousand tons of CO2e—i.e., an 81% increase for this group. Notably, this change alone represents 23% of the average annual emissions of all municipalities within the Amazon biome and 6.4% of Brazil's nationwide average. If we considered extending our findings to the rest of the Amazon municipalities—that is, to those excluded from our sample due to the absence of mixed-gender elections—, increasing the share of female mayors from 2% to just 20%—half the proportion in our sample—could reduce emissions by 104 thousand tons of CO2e. This represents a 35% decrease relative to the current annual emissions of these municipalities. While such extrapolation requires caution, this estimate provides a useful illustration of the potential scale of these effects.

Furthermore, the effect of women winning municipal elections on emissions is primarily driven by changes in land use within Amazon municipalities. Table 3 shows that the estimated effect is an annual reduction in emissions from land use activities of 1,462 thousand tons of CO2e per municipality when women won the election relative to when men won. In contrast, we find very small and statistically insignificant effects of a woman winning the election on emissions in other sectors, such as agriculture, energy, or waste (columns 2, 3, and 5, respectively).

[10] Large effect sizes are commonly reported in the literature when using similar methodologies. For instance, Dahis et al. (2023) study the impact of young politicians on emissions in Brazil and find estimated effects ranging from 72% to over 130%. Similarly, Jagnani and Mahadevan (2021) show that the election of women legislators in India leads to a reduction in crop-fire incidents, with effects between 33% and 100%. These large effects are not unique to environmental outcomes—Bochenkova et al. (2023) find impacts on domestic homicide rates between 50% and 70%. Other examples include Eslava (2024) and Chauvin and Tricaud (2024), where estimated effects relative to mean consistently exceed 60%.

[11] For this calculation, we consider the average number of municipalities per electoral round by dividing the number of municipality-terms reported in Table A.1 by four, as the dataset spans four electoral rounds and their respective mayoral terms.

Table 3: Female mayor and emissions by sector (in tons of CO2e)

	Total (1)	Agriculture (2)	Energy (3)	Land use (4)	Waste (5)
Panel A: Total					
Female mayor	-218,756**	5,628	2,913	-232,379**	882
	(101,193)	(17,163)	(5,017)	(93,063)	(781)
Mean outcome	291,668	91,178	17,003	172,653	6,348
Bandwidth	12.8	13.6	7.4	13.1	11.7
Observations	[1156, 1035]	[1224, 1063]	[722, 680]	[1179, 1041]	[1077, 977]
Panel B: Amazon region					
Female mayor	-1,509,865***	-40,342	-7,676	-1,461,500***	2,215
	(585,299)	(93,096)	(9,404)	(550,012)	(1,399)
Mean outcome	1,449,452	262,855	25,436	1,130,693	8,179
Bandwidth	12.8	10.8	11.7	13.2	6.4
Observations	[140, 125]	[130, 110]	[133, 114]	[144, 125]	[84, 77]
Panel C: Non-amazon region					
Female mayor	-27,744	8,114	4,717	-45,960	920
	(37,958)	(10,685)	(5,489)	(33,695)	(780)
Mean outcome	184,980	71,466	15,388	85,424	6,162
Bandwidth	16.2	14.7	7.3	15.6	14.1
Observations	[1275, 1051]	[1178, 1003]	[633, 598]	[1235, 1035]	[1141, 978]
Year & State FE	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the average annual emissions in tons of CO2e over the four-year term in all municipalities with mixed-gender elections (Panel A), the subsample of Amazon municipalities (Panel B), and the subsample of non-Amazon municipalities (Panel C). The results correspond to our baseline specification, similar to that in Column 1 of Table 2, which controls for year and state fixed effects. Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level in parentheses * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$.

5.2 Emissions intensity vs. economic activity

Using an IPAT decomposition framework as a lens (Ehrlich and Holdren, 1971), the reduction in emissions in tons of CO2e can be understood as stemming either from a decline in emissions intensity (CO2e/GDP) or from a contraction in economic activity. Table 4 presents the RD estimates of emissions in tons of CO2e per 1,000 BRL (Brazilian Reais) of GDP, calculated as the annual average over the four years of each mayoral term, which allows us to assess the first channel. The results show that emissions intensity decreases when a woman mayor is elected by a narrow margin compared to when a man is elected. This effect is driven by changes in land use within Amazon municipalities. When a woman wins the election in these municipalities, total greenhouse gas emissions in the Land Use sector decrease by 3.5 tons of CO2e per 1,000 BRL of GDP. In contrast, we find no evidence of effects on emissions intensity in other sectors or in non-Amazon municipalities.

Table 4: Female mayor and emissions intensity (CO2e/GDP) by sector

	Total	Agriculture	Energy	Land use	Waste
	(1)	(2)	(3)	(4)	(5)
Panel A: Total					
Female mayor	-0.546**	0.036	-0.001	-0.584**	-0.000
	(0.274)	(0.054)	(0.006)	(0.254)	(0.001)
Mean outcome	1.124	0.435	0.039	0.618	0.023
Bandwidth	10.4	14.2	11.5	10.4	11.7
Observations	[989, 892]	[1262, 1089]	[1055, 956]	[985, 890]	[1077, 980]
Panel B: Amazon region					
Female mayor	-3.504**	0.020	0.001	-3.509**	-0.006
	(1.652)	(0.296)	(0.015)	(1.606)	(0.004)
Mean outcome	3.871	0.799	0.041	2.996	0.025
Bandwidth	10.9	12.9	12.6	10.9	12.6
Observations	[130, 110]	[141, 125]	[139, 122]	[130, 110]	[140, 124]
Panel C: Non-amazon region					
Female mayor	-0.103	0.055	-0.001	-0.159	0.001
	(0.142)	(0.045)	(0.007)	(0.131)	(0.001)
Mean outcome	0.847	0.406	0.039	0.381	0.023
Bandwidth	13.9	13.2	12.8	13.5	12.3
Observations	[1131, 971]	[1081, 943]	[1033, 924]	[1101, 952]	[1001, 904]
Year & State FE	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is emissions intensity, measured in tons of CO2e per 1,000 BRL of GDP, calculated as the annual average over the four years of each mayoral term, in all municipalities with mixed-gender elections (Panel A), the subsample of Amazon municipalities (Panel B), and the subsample of non-Amazon municipalities (Panel C). The results correspond to our baseline specification, similar to that in Column 1 of Table 2, which controls for year and state fixed effects. Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level in parentheses * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$.

Regarding the second channel, we use our RD model to assess the impact of a woman winning an election on economic activity. Our findings indicate that the observed reductions in emissions are driven solely by changes in intensity and not by shifts in economic activity. In fact, Table 5 shows that when we apply the same RD design using municipal GDP, whether in levels or in logs, as the outcome variable, the effect of a woman winning the election is never statistically significant, which means that the reduction on emissions primarily operates through improved CO2e efficiency, i.e., fewer emissions per GDP.

Table 5: Female mayor and economic activity

	GDP (1)	Log GDP (2)
Panel A: Total		
Female mayor	-194,776	-0.018
	(177,825)	(0.091)
Mean outcome	385,406	12.065
Bandwidth	8.0	12.8
Observations	[781, 737]	[1152, 1033]
Panel B: Amazon region		
Female mayor	40,460	-0.176
	(129,346)	(0.219)
Mean outcome	381,909	12.329
Bandwidth	8.2	13.7
Observations	[103, 95]	[149, 126]
Panel C: Non-amazon region		
Female mayor	-158,560	-0.006
	(191,352)	(0.098)
Mean outcome	402,326	12.053
Bandwidth	10.4	13.5
Observations	[857, 766]	[1068, 913]
Year & State FE	Yes	Yes

Notes: The dependent variables are municipality GDP (Column 1) and its logarithm (Column 2), in all municipalities with mixed-gender elections (Panel A), the subsample of Amazon municipalities (Panel B), and the subsample of non-Amazon municipalities (Panel C). The regressions control for year and state fixed effects. Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level in parentheses * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$.

5.3 Effect on deforestation

According to MapBiomas (2024), over 90% of deforestation in the Amazon is driven by the creation of pastureland, a major contributor to greenhouse gas emissions in the Land Use sector. Deforestation plays a critical role in emissions, primarily by releasing carbon stored in trees and soil. When deforestation is reduced, the forest's carbon sequestration capacity is preserved, leading to lower emissions. To better understand how changes in land use contribute to the negative impact on emissions that we find, we now examine the impact of a woman winning the election on deforestation.

Table 6 presents the RD estimates of deforested hectares as a share of forest cover at the municipal level. The findings indicate that women winning elections lead to a reduction in deforestation exclusively in Amazon municipalities. According to the baseline specification in Column 1, a woman's victory in these municipalities reduces the deforested area by 3 percentage points relative to the total forest cover, which represents a 35% decrease relative to the baseline level. These results are consistent and highly robust across different specifications. In contrast, no significant effects on deforestation are observed in non-Amazon municipalities.[12]

Table 6: Female mayor and deforestation (as a share of forest cover)

	(1)	(2)	(3)	(4)
Panel A: Total				
Female mayor	-0.004	-0.004	-0.005	-0.005
	(0.004)	(0.005)	(0.005)	(0.005)
Mean outcome	0.049	0.049	0.049	0.049
Bandwidth	11.8	11.8	11.8	11.8
Observations	[1054, 950]	[1054, 950]	[1054, 950]	[1054, 950]
Panel B: Amazon region				
Female mayor	-0.033*	-0.032*	-0.033*	-0.029*
	(0.018)	(0.017)	(0.017)	(0.016)
Mean outcome	0.104	0.104	0.104	0.104
Bandwidth	11.5	11.5	11.5	11.5
Observations	[130, 110]	[130, 110]	[130, 110]	[130, 110]
Panel C: Non-amazon region				
Female mayor	-0.005	-0.004	-0.004	-0.005
	(0.004)	(0.004)	(0.004)	(0.004)
Mean outcome	0.045	0.045	0.045	0.045
Bandwidth	12.6	12.6	12.6	12.6
Observations	[974, 862]	[974, 862]	[974, 862]	[974, 862]
Year & State FE	Yes	Yes	Yes	Yes
Municipality controls	No	Yes	Yes	Yes
Mayor controls	No	No	Yes	Yes
Outcome t-1	No	No	No	Yes

Notes: The dependent variable is the total deforested area of forest in each municipality over each four-year term as a share of the total forest cover in each municipality during the baseline year (i.e., the year prior to the start of each term) in all municipalities with mixed-gender elections (Panel A), the subsample of Amazon municipalities (Panel B), and the subsample of non-Amazon municipalities (Panel C). Municipality controls include population size, GDP and share of value added by sector (agriculture, industry, services, and public administration). Mayor controls are age, level of education, marital status and party of affiliation (PT, PSDB, DEM, PMDB). Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level in parentheses * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$.

[12] Primary and secondary forests together make up 70% of the natural vegetation cover in Amazon municipalities. Among these forest formations, 83% correspond to primary forest—i.e., natural forest that has remained intact since the beginning of the series (1987) through the year of analysis—while the remaining 17% is secondary forest—i.e., forest that has regenerated after the original vegetation was removed or significantly altered by human activity. The results in Table 6 are primarily driven by changes in primary forest. In contrast, we find no effects of women winning the election on changes in secondary forest. When we replicate our analysis considering changes in the entire natural vegetation cover—including savanna, mangrove, wetland, grassland, and other non-forest natural formations—rather than just forest, the results remain robust. Results are available upon request.

This seemingly smaller impact on deforestation compared to the effects described earlier on emissions suggests that changes in deforestation alone may not fully explain the observed reductions in emissions. For instance, while deforestation is a key driver of emissions, other factors also contribute to emissions in the Land Use sector, such as the burning of forest residues.[13]

5.4 Robustness checks

In this subsection, we discuss six empirical validation tests based on (i) placebo outcomes, (ii) sensitivity to bandwidth choices, (iii) sensitivity to outliers, (iv) exclusion of observations near the cutoff, (v) sensitivity to different kernels and polynomial orders, and (vi) exclusion of municipalities that were part of the List of Priority Municipalities (LPM).

Placebo outcomes. As a placebo exercise, we replicated the analyses presented in Tables 2, 3, and 6 for our main outcomes, using lagged outcome variables (e.g., emissions and deforestation in each municipality from the previous term) instead of contemporaneous ones. As expected, the results from this exercise reveal no statistically significant effects for any of the outcomes analyzed (see Table A.2 in the Appendix).

Sensitivity to bandwidth choice. Figure A.5 in the Appendix shows bandwidth robustness tests for the effect of female mayors on our main outcomes. All estimates are derived from running Equation 1. Optimal bandwidths are marked by red vertical lines, and the figures also depict 90% confidence intervals. The interpretation of this exercise requires careful consideration, as selecting the bandwidth is a critical decision in RD analysis. According to Cattaneo et al. (2019), "bandwidths much larger than the optimal bandwidth will lead to estimated RD effects that have too much bias, and bandwidths much smaller than the optimal choice will lead to RD effects with too much variance. In both cases, point estimation will be unreliable, and so will be the conclusions from the falsification test." Therefore, exploring sensitivity to bandwidth choices is meaningful only within narrow ranges around the optimal bandwidth. We observe that, indeed, within narrow ranges around the optimal bandwidth, all our results remain robust to different bandwidth lengths. Moreover, as we further increase the bandwidth, the point estimates—while often not statistically significant—consistently retain the same sign as those estimated with the optimal bandwidth and do not differ significantly from them.

Sensitivity to outliers. For total emissions in tons of CO2e, our results show reductions between 75% (when considering all municipalities with mixed-gender close elections) and 104% (when restricting to Amazon municipalities) in the average annual municipal emissions per mayoral term when a woman is elected. These large reductions could be driven

[13] Although this practice is related to deforestation, the emissions generated by burning are not limited to the destruction of tree residues; they also include the release of carbon stored in the soil.

by outliers. Figure A.6 in the Appendix presents the results of an outlier robustness test where we modify the distribution of total emissions by smoothing extreme values using the subsample of Amazon municipalities. The smoothing consists of replacing the value of the observations below or above a certain threshold with the value of that threshold.[14] Thresholds are defined by the mean value of total emissions minus/plus its standard deviation scaled by factors ranging from 1 to 3. We then re-estimate 1 using the smoothed distributions. The results show that the effect size, the coefficient β relative to the baseline, gets reduced when we smooth observations. Depending on the smoothing option, the estimated effect ranges between a 104% (our main result) to a 50% reduction relative to the baseline. Importantly, the effects are statistically significant in all cases.

Sensitivity to observations near the cutoff (the "donut hole" approach). We analyze the sensitivity of our results to the exclusion of observation units located very close to the cutoff. If manipulation of the margin of victory occurs, it is reasonable to assume that the units closest to the cutoff are the most likely to be involved in such behavior. Therefore, we exclude these observations and re-estimate Equation 1 using the remaining sample. This approach also helps assess sensitivity to the assumptions made in local polynomial estimation, as observations closest to the cutoff can exert significant influence on fitting the local polynomials (Cattaneo et al., 2019). Figure A.7 in the Appendix illustrates the results from repeating this exercises 10 times, starting from no exclusions (the baseline case) and progressively excluding observations within 0.1%, 0.2%, 0.3%, up to 1% of the cutoff. In all cases, the analysis yields consistent conclusions: when excluding observations near the cutoff point, the point estimates remain highly stable, as do the confidence intervals.

Different kernel and polynomial order. In our estimations, we use the recommended triangular kernel function (Cattaneo et al., 2019). This function assigns the highest weight to observations at the cutoff, with weights decreasing symmetrically and linearly as the score deviates from the cutoff, and gives zero weight to observations outside the optimal bandwidth. As a robustness check, we also run Equation 1 using a uniform kernel. This kernel assigns equal weight to all observations within the bandwidth and zero weight outside it. Regarding the polynomial order, our main specification uses a first-order polynomial, which is the recommended and the default in most applications when the appropriate bandwidth is selected (Cattaneo et al., 2019). However, to further assess robustness of our findings, we run Equation 1 using a second-order polynomial. Columns 1 and 5 of Tables A.3 and A.4 in the Appendix replicate our main results—i.e., those obtained using a triangular kernel and a first-order polynomial. Columns 2, 4, 6, and 8 present the results with a second-order polynomial, while columns 3, 4,

[14]Since we use net emissions—calculated as emissions minus removals—some municipalities may exhibit large negative values due to high levels of carbon removals. Therefore, it is important to also adjust for extreme negative values.

7, and 8 show estimates with a uniform kernel. Our findings are robust to the use of a uniform kernel and/or second-order polynomials, except in the case of deforestation, where, although the sign and magnitude of the estimates remain largely unchanged, some results become significant at the 10% level, while others slightly lose significance.

Sensitivity to exclusion of priority municipalities in our sample. We assess the incidence of the LPM in our main results. The LPM was implemented by the Brazilian Ministry of Environment in 2008 and it was aimed to curb deforestation by focusing on municipalities with high deforestation rates. Initially, 36 municipalities were included, and over time, the list grew to 70 municipalities, with additional municipalities added in 2009, 2011, 2017, 2018, and 2021. Municipalities were required to lower deforestation and register private landholdings in a national environmental database (SICAR). The LPM imposed sanctions such as credit restrictions and market embargoes, encouraging collective and individual actions to comply. According to dos Santos Massoca and Brondízio (2022), local leadership played a pivotal role in these outcomes, as municipalities with strong coordination among local agents, NGOs, and governments were more successful in reducing deforestation and meeting the policy's removal criteria. We evaluate whether our results hold when excluding from the sample the municipalities that were part of the LPM between 2008 and 2020. Data on the municipalities included in the list are available from the *Ministério do Meio Ambiente e Mudança do Clima* (Ministry of the Environment and Climate Change). While only 10 municipalities from the LPM are included in our estimation sample, our results could be driven by this policy if, for instance, female mayors of municipalities included in the LPM assigned more effort to comply with the targets than male mayors. To analyze this, we re-estimate the RD models, excluding those 10 municipalities. Our results in Figure A.8 remain consistent, suggesting that the LPM policy is not behind the better performance of women in deforestation and emissions in the overall sample.

5.5 Gender effects and compensating differentials

Marshall (2024) highlights the concern that female candidates in close elections may be more competent than equally popular male candidates if voters hold biases against women: i.e., in cases of gender discrimination, a female candidate receiving the same vote share as a male candidate likely possesses compensating attributes, such as higher ability, that offset her initial disadvantage. These compensating attributes might be irrelevant to our outcomes or counterbalanced by idiosyncratic electoral shocks (Marshall, 2024). However, if they do influence outcomes, our estimates could reflect a compound effect of a bundled treatment rather than an isolated gender effect.

This concern raises a critical question for our study: could the compensating attributes of positively selected female politicians—i.e., those that allow them to secure comparable votes despite gender biases—explain our results?

Isolating the causal effect of politician gender in a close-election RD design requires at least one of the following conditions to hold: (i) candidate gender does not influence vote shares, or (ii) compensating differentials do not affect the outcome of interest (Marshall, 2024). If neither condition is satisfied, compensating differentials may introduce asymptotic bias into the RD estimates. While condition (i) is challenging to justify, we argue that condition (ii) is more likely to hold in our context.

We present two pieces of evidence suggesting that compensating differentials are unlikely to drive our findings. First, we analyze whether skill level differences between female and male mayors could account for the observed effects. Among potential compensating differentials, skills emerge as the most plausible confounder of the estimated gender effect. Although we cannot directly measure traits such as ability, intelligence, or awareness of environmental issues, observable characteristics such as education can serve as partial proxies. Consistent with the positive selection of female candidates, our analysis shows that closely elected female mayors are, on average, more educated than their male counterparts. In Section 4, we demonstrate that most predetermined characteristics are balanced near the cutoff, except that female mayors are more likely to have a college degree. If higher education correlates with a greater propensity to implement environmentally protective policies, this could potentially drive our results. To address this possibility, we conduct two analyses. First, we control for mayoral education in our main model. As shown in previous subsections, the point estimates remain virtually unchanged. Second, we estimate an RD model in which the treatment variable is the mayor's education level rather than gender, comparing municipalities where a college-educated candidate narrowly won with those where a non-college-educated candidate narrowly won. Figure A.9 in the Appendix shows that education level has no significant impact on the main outcomes analyzed. Assuming that a college degree is associated with the same level of skills for both men and women, this evidence supports the validity of condition (ii), as differences in education do not appear to affect the outcomes of interest.

Second, as Marshall (2024) argues, compensating differentials would not introduce bias if voters do not care about the outcomes of interest to researchers—in our case, environmental issues. As we will show, the evidence in Section 6 suggests that during the years analyzed, voters do not strongly prioritize environmental concerns. If they had, we would expect environmental issues to feature more prominently in the government proposals of the mayoral candidates. Instead, only 0.28% of the words in these proposals are related to environmental topics, whereas 2.34% are linked to education, 1.57% to health, and 1.28% to employment.

These two pieces of evidence suggest that our findings may not be merely driven by compensating differentials. However, we acknowledge the challenges of comprehensively measuring or observing the compensating differentials. Many potential factors, such as non-cognitive skills (e.g., negotiation ability), social preferences, aptitudes related to long-term outcomes, political experience and political networks, are unobservable. These attributes may not only help women win elections but also enable them to implement less popular policies or initiatives requiring longer-term commitments and broader support, particularly relevant in the context of environmental issues. Thus, while our previous analysis shows that the estimated effect of electing women as mayors on environmental outcomes does not stem from certain skill dimensions, such as education, we cannot rule out that it might also capture other influences, such as those discussed above.

6 Mechanisms

In this section, we examine potential mechanisms that could explain the positive environmental impact of narrowly electing a female mayor over a male counterpart. Specifically, we explore whether female and male mayors differ in the following areas: i) the emphasis they place on the environment in their government proposals, ii) their environmental policies, and iii) their enforcement of environmental regulations. To achieve this, we estimate models similar to the one presented in Equation 1, using these variables as outcomes and controlling for mayoral term and state fixed effects. For simplicity, we present the results graphically, showing the estimated β along with the corresponding 90% confidence intervals.

Government proposals. When running for office, candidates present their government proposals, which serve as an initial roadmap for governance, reflecting candidates' policy priorities and commitments. If female and male mayors differ in the emphasis they place on environmental issues at this early stage, these differences may translate into distinct policy actions once in office, ultimately affecting environmental outcomes. Thus, the content of government proposals provides insights into a potential mechanism linking mayoral gender to observed differences in emissions and deforestation.

To explore whether female and male elected mayors differ in their proposed policies, we obtain government proposals of candidates running for mayor from the open data portal of the *Tribunal Superior Eleitoral.* We apply a text analysis methodology, a keyword-based approach, to create measures that capture emphasis on specific topics within the elected mayors government proposals. First, we define a set of topics of interest using AI. Although our main interest is in environment and climate change, we also explore gender differences in other topics including women's issues, social assistance, security, health, education, culture, children, and administration. Next, based on the text of the government proposals, we also use AI to generate a group of words associated with each topic.[15] Finally, we count the times these words appear in each proposal and calcu-

[15] We provided ChatGPT with a subset of government proposals and asked it to analyze them to identify the main topics. We repeated this process with different subsets of proposals to validate the consistency of the identified topics and then manually validated the relevance of the topics. In each iteration, we also asked ChatGPT to suggest the most frequently used words for each topic. The resulting word lists were further refined through manual verification. For example, for the environmental topic, the words identified in Portuguese include: *ambiente, educação ambiental, reflorestamento, proteção ambiental, amazonia, desmatamento, floresta amazonico, biodiversidade, desflorestamento*. An approxi-

late the ratio between this number and the total number of words in the proposal. The text of each proposal and the keywords were preprocessed by removing special characters, filtering out common and uninformative words, and applying stemming. For instance, we find that 0.28% of the words in the proposals are related to environmental issues, and this proportion remains consistent across both the mixed-gender elections sample and the other municipalities (see Table A.1). Since government proposals are only available for the 2012 and 2016 mayoral elections, we explore whether female and male elected mayors differ in their proposals using information from these two electoral cycles.

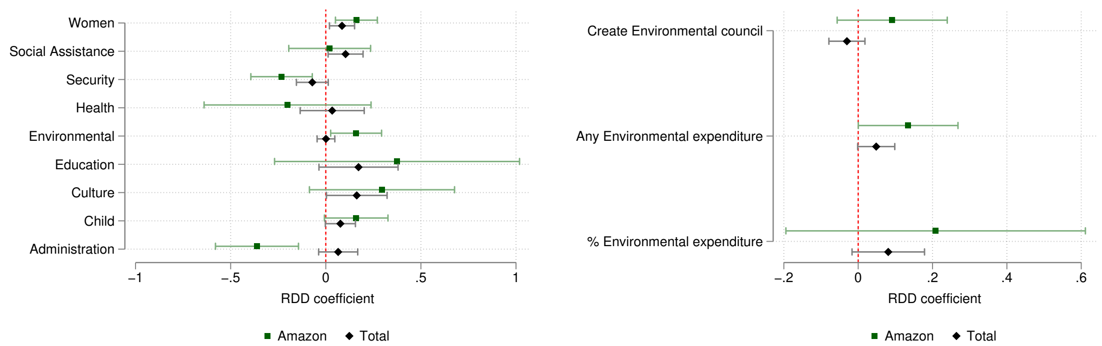
Figure 3a shows that female and male elected mayors differ substantially in their proposals. Female candidates who won the election by a narrow margin tend to allocate more space to topics such as the environment, women, social assistance, education, culture, and children, though results are not always statistically significant. Government proposals of male mayors, on the other hand, mention security, health and administration more often than female proposals, especially in municipalities with Amazon biome. For environment specifically, the fraction of words associated with this topic is 0.16 percentage points larger in female elected mayors' proposals than in male elected mayors' proposals in municipalities with Amazon biome. The effect represents a 50% increase relative to the share of words associated with the environment in Amazon municipalities with male mayors. Moreover, the effect is close to the estimated gap in favor of female proposals in women's and children's topics in Amazon municipalities and around half the size of the gap in favor of male proposals on the administration topic. This result suggests that the better performance of female leaders in climate change mitigation in Amazon municipalities might already be reflected in their government proposals.

Environmental policies. We also assess the role of the effort municipalities devote to environmental policy, proxied by the creation of environmental councils and the availability and allocation of budgetary resources dedicated to environmental purposes. Data on public spending in environmental management at the municipal level is available from *Basedosdados*, a non-governmental and open source organization. *Basedosdados* harmonizes and combines data from the National Treasury for 2004 to 2012 and from the Accounting and Fiscal Information System for 2013 to 2019. The data covers spending on environmental preservation and conservation, environmental control, recovery of degraded areas, water resources, meteorology, and other actions. Information on whether the municipality has an environmental council and the date of creation is available in IBGE's MUNIC (*Perfil dos Municipios Brasileiros*), a survey on the structure, dynamics, and operation of municipal public institutions carried out by the *Instituto Brasileiro de Geografia e Estatística* (IBGE). Based on these data, we construct several variables that serve as proxies for the effort municipalities devote to environmental policy. Our

mate translation of these terms into English is: *environmental, environmental education, reforestation, environmental protection, amazon, deforestation, amazon rainforest, biodiversity, environment.*

Figure 3: Political proposals, public spending and institutions

(a) Government proposals (b) Environmental policies



Notes: These figures show the β coefficient and its 90% confidence interval from estimating Equation 1 for all municipalities with mixed-gender elections and for the subsample of Amazon municipalities. The dependent variables are: number of words related to each topic in relation to the total number of words in the proposal (Panel a) and a binary variable indicating if the mayor created an environmental council during the four-year term, another binary indicator showing whether the municipality made any environmental expenditure, and a variable measuring the percentage of the municipal budget allocated to environmental expenditures (Panel b). Estimates obtained using local linear estimators with a triangular kernel and optimal bandwidth based on Calonico et al. (2014). All estimates account for state and round fixed effects.

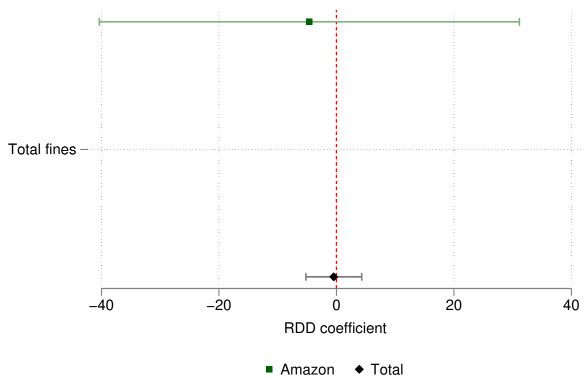
outcomes of interest are: a binary variable indicating if the municipality established an environmental council during the mayors' mandate, another binary indicator showing whether the municipality made any environmental expenditure over the four-year term of the mayors mandates, and a variable measuring the percentage of the municipal budget allocated to environmental expenditures in each four-year term. Table A.1 shows the averages of the variables related to Public spending and Institutions. In the sample with mixed-gender elections, 55% of the municipalities have an environmental council and, while 57% of the municipalities made any environmental expenditure, this expenditures represents only 0.48% of the total budget on average. Although the percentage of municipalities with an environmental council is slightly higher in the remaining municipalities (60%), there are no statistically significant differences between municipalities with and without mixed-gender elections for the other variables.

The results in Figure 3b suggest that, once in office, female leaders respond differently to climate change in terms of the allocation of resources to environmental management. Specifically, in line with the findings presented in Section 5, the difference is evident in municipalities with Amazon biome. When a woman wins the election in Amazon municipalities, the likelihood of these municipalities investing in environmental initiatives increases by 13 percentage points, and the share of the budget allocated to these initiatives rises by 0.2 percentage points, though this effect is not statistically significant. Amazon municipalities led by women are also more likely to create an environmental council compared with those led by men, but this effect is not significant in statistical terms.

Enforcement of environmental regulations. To explore this potential mechanism, we examine whether female and male mayors differ in the number of environmental fines issued during their mayoral term due to environmental infractions detected in their municipalities.[16] We use data on the number of environmental fines issued throughout the mayoral term due to deforestation infractions detected in each municipalities. These data come from the Brazilian Institute of Environment and Renewable Natural Resources. According to this source, municipalities with mixed-gender elections issued an average of three fines related to deforestation infractions (see Table A.1), and this number is not significantly different from the average number of fines issued in other municipalities.

Although differences between female and male mayors in inspection activities may lead to discrepancies in the number of fines, the direction of the effect is not clear. For instance, higher enforcement efforts could reduce the number of fines in equilibrium if land users update their perceived probability of being caught, thereby reducing illegal deforestation. Figure 4 shows no statistically significant gender differences in the number of fines due to deforestation infractions in the entire sample of municipalities or those with Amazon biome. Given the limitation of the number of environmental fines as a proxy of enforcement effort mentioned above, we interpret this result as suggestive evidence of differential enforcement efforts between female and male mayors not driving our main results.

Figure 4: Female mayor and number of environmental fines



Notes: These figures show the β coefficient and its 90% confidence interval from estimating Equation 1 for all municipalities with mixed-gender elections and for the subsample of Amazon municipalities. The dependent variables are: Total deforested area in hectares per municipality over each four-year mandate (Panel a), emissions per unit of municipal GDP (Panel b), and total number of fines due to deforestation infractions per mayoral term (Panel c). Estimates obtained using local linear estimators with a triangular kernel and optimal bandwidth based on Calonico et al. (2014). All estimates account for state and round fixed effects.

[16] Although the institution responsible for issuing environmental infraction reports is the Brazilian Institute of Environment and Renewable Natural Resources, a federal institution, the competence for environmental inspections is shared with the states, municipalities, and the federal district.

7 Conclusions

Climate change has significant social and economic negative implications and requires adequate and timely policies. Understanding the role of women in policy decisions regarding climate change is important given the evidence indicating that many social outcomes improve when the leader is a woman and that women are generally more aware and concerned than men about climate change. In this paper, we have analyzed how female political leaders impact climate change policy actions and environmental outcomes using data from mixed-gender close mayoral races in Brazilian municipalities and applying a Regression Discontinuity design.

Our findings reveal a significant positive effect on environmental outcomes at the municipal level when a woman narrowly defeats a male opponent in a mayoral election, particularly in Amazon municipalities. In these municipalities, annual greenhouse gas emissions decrease by 1,510 thousand tons of CO2e when a woman is elected mayor. This implies that, without the effect of female mayors, annual emissions would have increased by 81% in mixed-gender election municipalities in the Amazon. Notably, this change alone represents 23% of the average annual emissions of all municipalities within the Amazon biome and 6.4% of Brazil's nationwide average.

Moreover, the reduction in emissions is driven by a decrease in emissions intensity (CO2e/GDP) within the Land Use sector, without changes in municipal economic activity. Part of the reduction on emissions in the Land Use sector is a attributable to a decline in deforestation. Specifically, female-led municipalities in the Amazon experience a reduction in deforestation compared to male-led municipalities, with a 3 percentage point decrease in the deforested area relative to total vegetation cover, representing a 32% reduction compared to the baseline deforestation levels.

Furthermore, our exploration of the underlying mechanisms indicate that female mayors adopt distinct approaches to climate change public policy, particularly in the Amazon region. The policy proposals put forth by female elected mayors feature 0.16 percentage points more references to environmental-related terms than those proposed by their male counterparts, representing a 50% increase relative to the baseline. Moreover, the election of a woman significantly increases the likelihood of investing in environmental initiatives by 13 percentage points. Importantly, our findings suggest that differences in the enforcement of environmental regulations do not explain our findings.

Finally, we show that these results are robust across various checks. Specifically, they hold when applying different bandwidths, excluding municipalities located very close to the cutoff, and employing different kernel and polynomial functions. Additionally, our findings hold when excluding municipalities there were part of the List of Priority Municipalities, indicating that the results are not driven by this policy, and we also show that differences in the observed skill levels of female and male mayors do not explain the results.

While our study focuses on the Amazon, a region of critical global environmental significance, further research is needed to explore whether similar patterns emerge in other contexts. Expanding this analysis to different geographic regions, particularly those facing distinct environmental and governance challenges, could provide a broader understanding of the role of female leadership in climate policy. For instance, examining the impact of female political leaders in regions affected by industrial pollution, water scarcity, or extreme weather events could shed light on whether their influence extends beyond deforestation and land use policies. Additionally, it would be of great interest to investigate how the presence of strong national environmental policies or external international pressures, such as global environmental agreements or climate finance mechanisms, might interact with gender differences in leadership. By expanding this analysis to a broader range of regions, we could better assess whether women's leadership has consistently positive environmental impacts or if such effects are context-dependent, thus offering more generalizable insights into the role of women in climate governance.

Summarizing, our analysis shows that electing a woman as mayor leads to significant improvements in climate-related outcomes compared to electing a male mayor in Amazon municipalities. These effects likely stem from gender differences in public policy decisions. Although extrapolating these results to other contexts is not straightforward, this evidence underscores the value of increasing women's political participation, as it not only strengthens environmental governance but also addresses key climate challenges. In short, our findings highlight the role of women as agents of environmental change.

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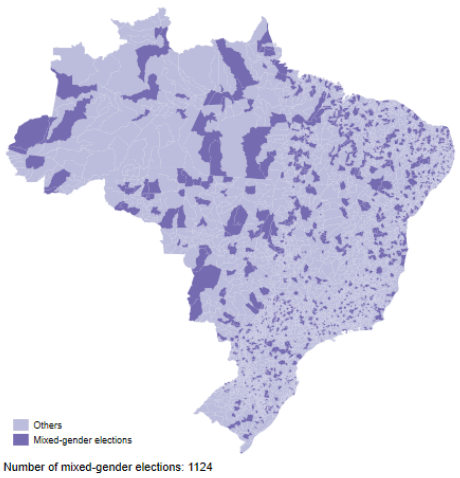
A Tables and Figures

Figure A.1: Distribution of mixed-gender elections

(a) Round 2004

(b) Round 2008

(c) Round 2012



(d) Round 2016

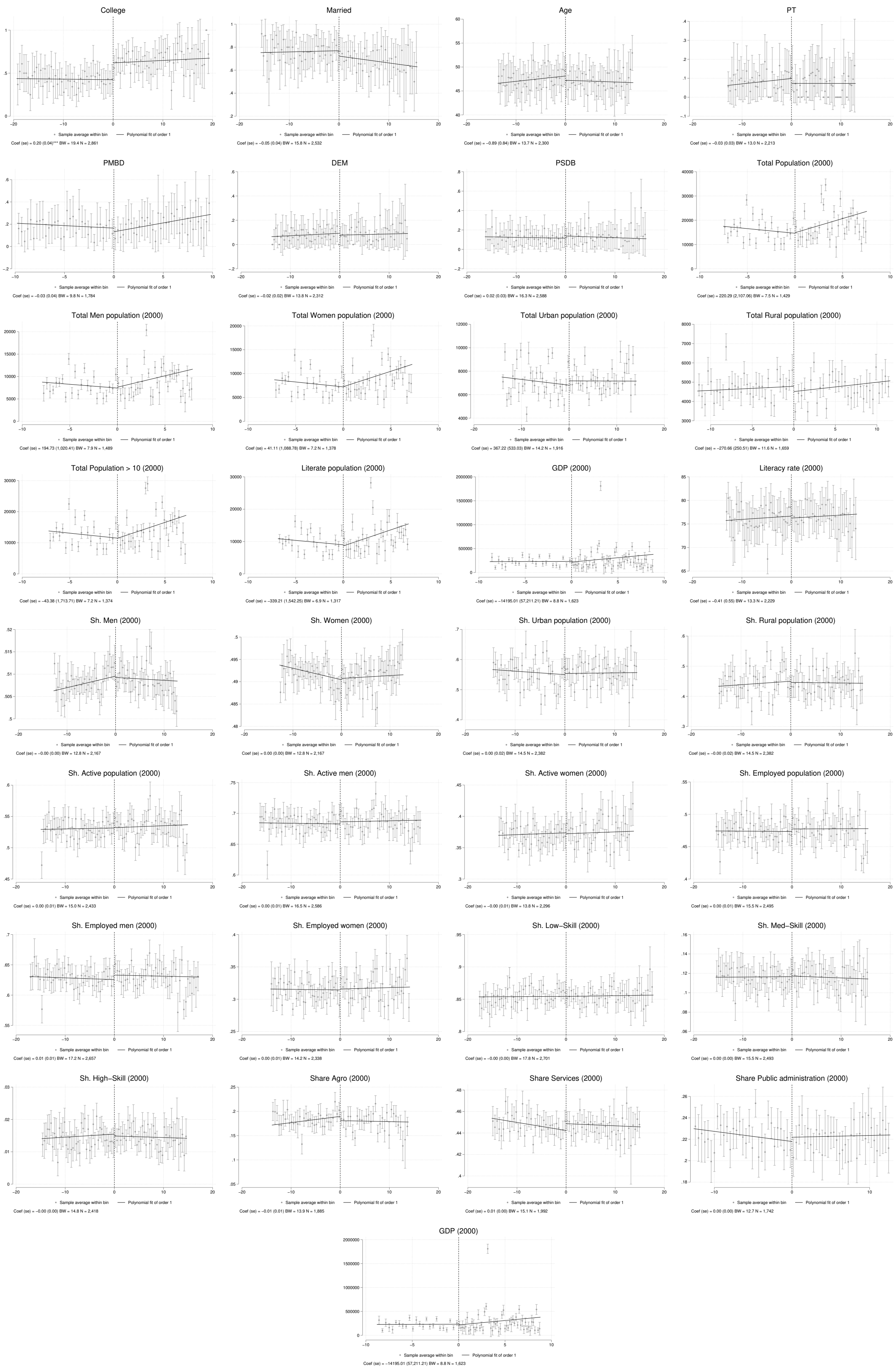
Note: Mixed-gender elections are defined as elections where the two candidates with the largest share of votes are a man and a woman. “Others” are the rest of the municipalities.

Table A.1: Descriptive statistics

	Municipalities with mixed-gender elections		Rest of municipalities			
	Mean	Obs.	Mean	Obs.	Difference	P-value
Panel A: Geographic and economic characteristics						
Total area in ha.	170213	3,888	145671	16,890	24541	0.01
GDP (thousands of constant Brazilian reais)	719438	3,889	852787	16,893	-133349	0.28
GDP per capita (constant Brazilian reais)	21360	3,889	23982	16,893	-2623	0.00
Agriculture value added/GDP	0.176	3,889	0.187	16,893	-0.010	0.00
Industry value added/GDP	0.116	3,889	0.127	16,893	-0.011	0.00
Services value added/GDP)	0.357	3,889	0.375	16,893	-0.018	0.00
Public administration value added/GDP	0.296	3,889	0.256	16,893	0.040	0.00
Panel B: Population characteristics						
Total population	25,862	3,889	27,429	16,893	-1,566	0.48
Share of urban population in 2000	0.574	3,864	0.585	16,695	-0.010	0.01
Share of rural population in 2000	0.426	3,864	0.415	16,695	0.010	0.01
Share of active women in 2000	0.372	3,864	0.394	16,695	-0.022	0.00
Share of employed women in 2000	0.313	3,864	0.335	16,695	-0.021	0.00
Share of low skilled in 2000	0.850	3,864	0.839	16,695	0.012	0.00
Share of medium skilled in 2000	0.120	3,864	0.131	16,695	-0.011	0.00
Share of high skilled in 2000	0.016	3,864	0.019	16,695	-0.003	0.00
Panel C: Mayor characteristics						
Female	0.42	3,889	0.02	16,893	0.40	0.00
College	0.53	3,889	0.45	16,893	0.08	0.00
Married	0.73	3,889	0.79	16,893	-0.06	0.00
Age	47.23	3,889	47.77	16,893	-0.54	0.00
Party PT	0.08	3,887	0.09	16,893	-0.01	0.17
Party PMBD	0.19	3,887	0.20	16,893	-0.00	0.75
Party DEM	0.08	3,887	0.08	16,893	-0.00	0.31
Party PSDB	0.14	3,887	0.14	16,893	-0.01	0.35
Other political party	0.51	3,887	0.49	16,893	0.02	0.03
Panel D: Emissions per municipality						
Emissions Agriculture	101,252	3,889	95,258	16,893	5,994	0.08
Emissions Energy	36,971	3,855	38,741	16,778	-1,770	0.63
Emissions Waste	8,285	3,889	8,915	16,893	-630	0.02
Emissions Land use	82,885	3,888	70,858	16,890	12,027	0.43
Emissions Total	229,047	3,889	213,496	16,893	15,552	0.36
Emissions Total Amazon	779,483	453	774,242	1,538	5,241	0.97
Emissions Total non-Amazon	170,750	3,295	177,300	14,985	-6,550	0.40
Panel E: Deforestation per municipality						
Total deforestation/baseline forest	0.05	3,770	0.05	16,552	0.00	0.09
Total Amazon deforestation/baseline forest	0.10	453	0.08	1,538	0.02	0.00
Total non-Amazon deforestation/baseline forest	0.04	3,295	0.04	14,985	-0.00	0.65
Panel F: Environmental governance and expenditures						
Municipality with an Environmental Council	0.55	3,889	0.60	16,893	-0.04	0.00
Municipality with environmental expenditure	0.57	3,875	0.59	16,836	-0.01	0.12
Percentage of environmental expenditure	0.48	3,875	0.47	16,836	0.01	0.32
Total environmental fines	3.08	3,889	2.57	16,893	0.51	0.09
Percentage of environmental related words	0.28	1,892	0.28	6,884	-0.00	0.76

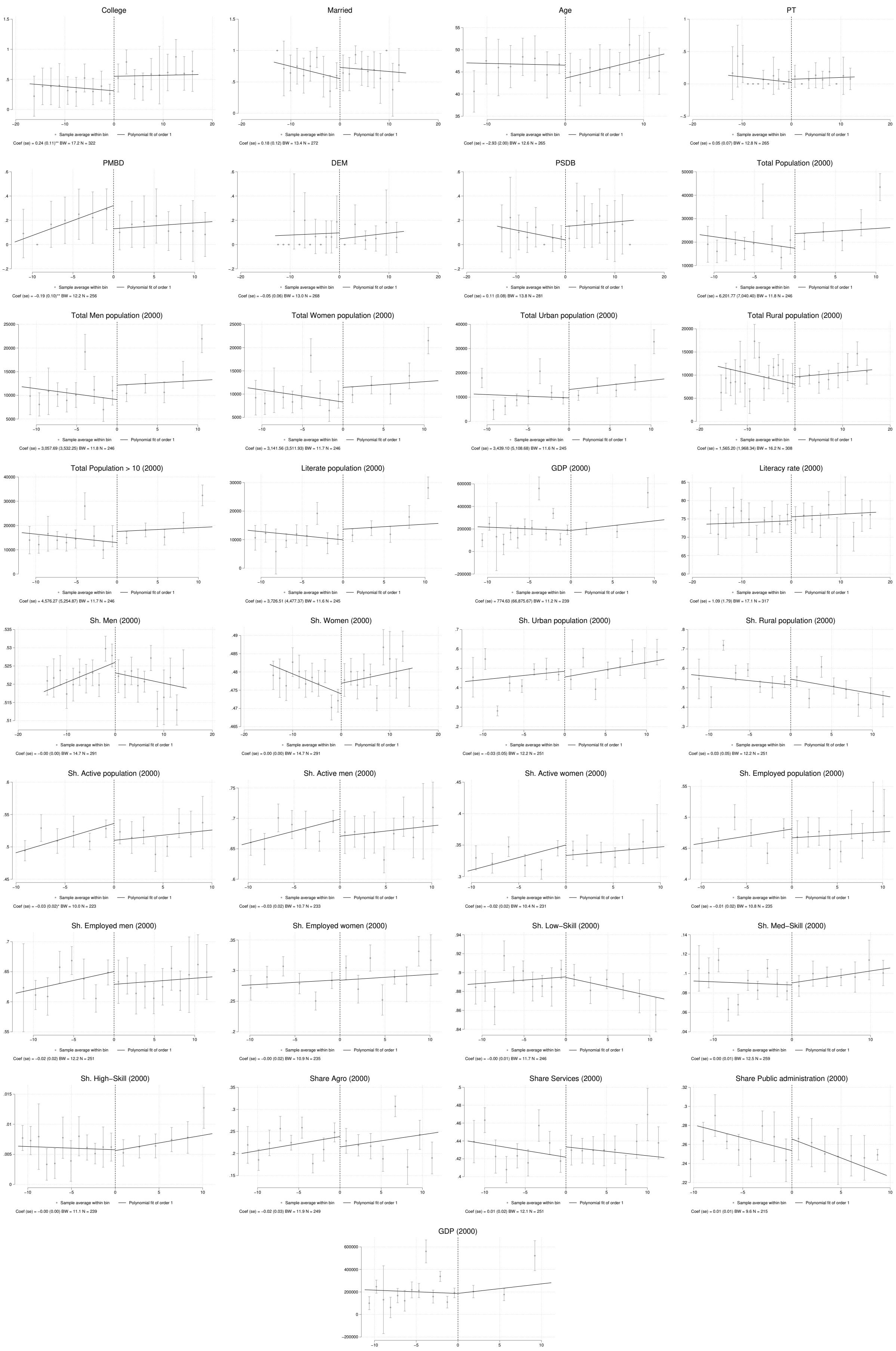
Notes: The table considers all municipalities where elections were resolved in the first round, without the need for a rerun and without irregularities. These municipalities are divided into two groups: municipalities with mixed-gender elections (defined as those where the two candidates with the largest share of votes are a man and a woman) and the remaining municipalities. The total number of observations refers to the municipality-term units. Difference and p-values refer to the difference between the means of the two samples and the statistical significance of this difference. Emissions are measured as the average annual emissions in tons of CO_2e for each four-year term of the mayors mandate. Deforestation is the total deforestation of forest cover in each municipality over the four-year term of the mayors' mandates, measured as a percentage of the total forest cover in each municipality during the baseline year, which is the year prior to the start of each term. The share of active women in 2000 is measured as the total number of economically active women aged 10 years or older divided by the total number of women aged 10 years or older in 2000, while the share of employed women in 2000 is calculated as the total number of employed women aged 10 years or older divided by the total number of economically active women aged 10 years or older in 2000. The share of low-skilled, medium-skilled, or high-skilled individuals is measured as the total number of people aged 10 years or older with 0 to 8 years of education, 9 to 13 years of education, or 14 or more years of education in 2000, respectively, divided by the total number of people aged 10 years or older in 2000.

Figure A.2: Covariates balances RD



Note: These figures show graphically the balance of mayors' and municipalities' characteristics. Estimates obtained using local linear estimators with a triangular kernel and optimal bandwidth based on Calonico et al. (2014). All estimates account for state and round fixed effects. Robust standard errors clustered at the municipal level in parentheses * p < 0.1, ** p < 0.05 and *** p < 0.01.

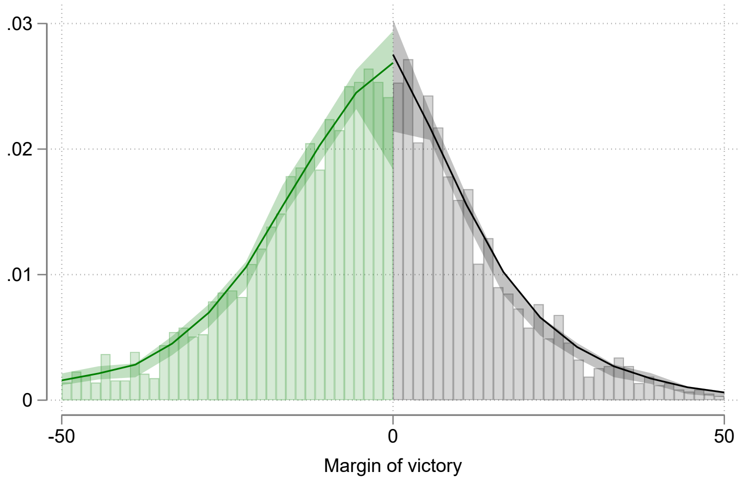
Figure A.3: Covariates balances RD (Amazon)



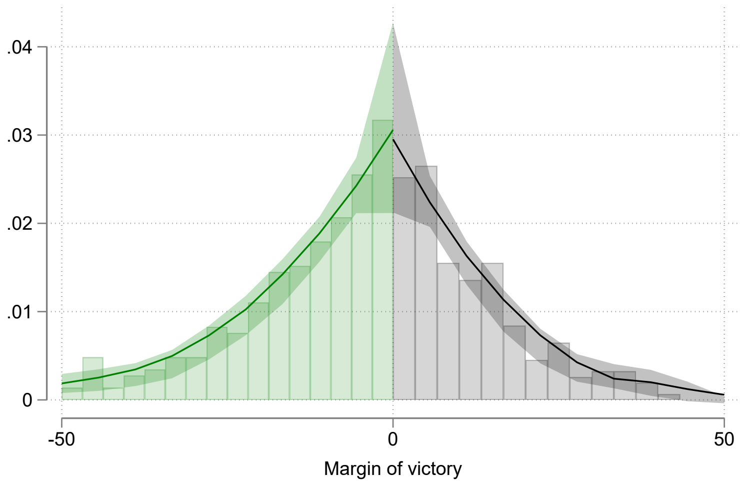
Note: These figures show graphically the balance of mayors' and municipalities' characteristics. Estimates obtained using local linear estimators with a triangular kernel and optimal bandwidth based on Calonico et al. (2014). All estimates account for state and round fixed effects. Robust standard errors clustered at the municipal level in parentheses * p < 0.1, ** p < 0.05 and *** p < 0.01.

Figure A.4: Continuity of the density of the margin of victory

(a) Total



(b) Amazon region



Notes: The figures show the histogram estimate of the margin of victory and the local polynomial density estimated using Cattaneo et al. (2018) for all municipalities with mixed-gender elections (Panel a) and for the subsample of Amazon municipalities (Panel b).

Table A.2: Female mayor and environmental outcomes in the previous term

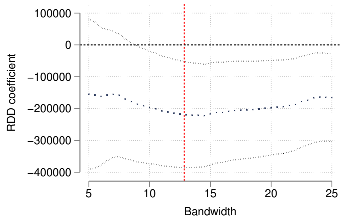
	(1) Total emissions	(2) Land use emissions	(3) Share Deforestation
Panel A: Total			
Female mayor	70,012	-17,565	0.003
	(89,408)	(75,773)	(0.005)
Mean outcome	297,667	146,693	0.048
Bandwidth	10.3	11.0	17.2
Observations	[974, 877]	[1032, 923]	[1454, 1210]
Panel B: Amazon region			
Female mayor	322,064	6,244	-0.016
	(486,999)	(466,482)	(0.015)
Mean outcome	1,146,551	791,306	0.111
Bandwidth	10.5	11.3	18.8
Observations	[128, 108]	[132, 112]	[229, 191]
Panel C: Non-amazon region			
Female mayor	48,612	-3,804	0.005
	(45,868)	(27,984)	(0.004)
Mean outcome	194,452	75,180	0.043
Bandwidth	11.6	11.1	15.7
Observations	[936, 839]	[908, 806]	[1260, 1053]
Year & State FE	Yes	Yes	Yes

Notes: The dependent variables are average annual emissions in tons of CO2e in the previous four-year term (columns 1 and 2) and deforestation as a share of baseline forest cover (column 3) in all municipalities with mixed-gender elections (Panel A), the subsample of Amazon municipalities (Pane B), and the subsample of non-Amazon municipalities (Panel C). Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level in parentheses * $p < 0.1$, ** $p < 0.05$ and *** $p < 0.01$.

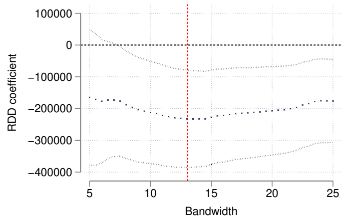
Figure A.5: Sensitivity to bandwidth choice.

A. All municipalities with mixed-gender elections.

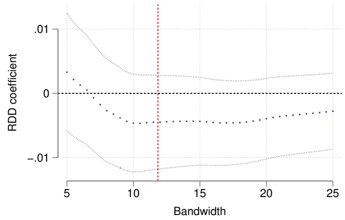
(a) Emissions in tons of CO2e



(b) Emissions in tons of CO2e Land use

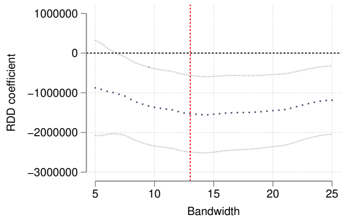


(c) Deforestation as share of forest cover

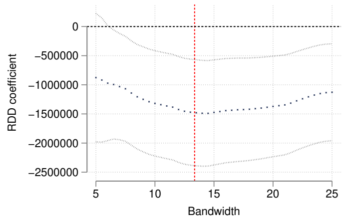


B. Amazon municipalities.

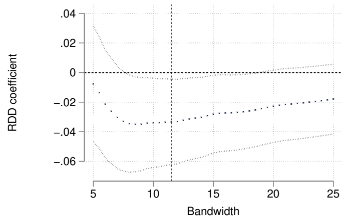
(d) Emissions in tons of CO2e



(e) Emissions in tons of CO2e Land use



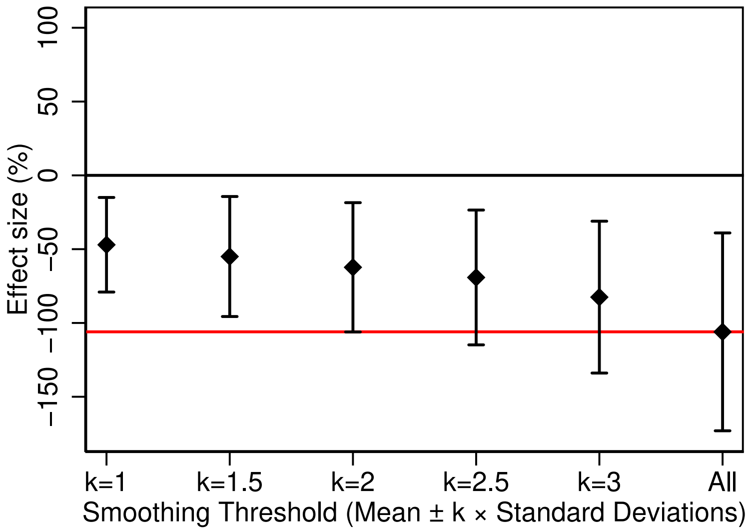
(f) Deforestation as share of forest cover



Notes: These figures show the β coefficient and its 90% confidence interval from estimating Equation 1 using different bandwidth lengths. The optimal bandwidth, marked by red vertical lines, is based on Calonico et al. (2014). Estimates are obtained using local linear estimators with a triangular kernel.

Figure A.6: Sensitivity to outliers.

(a) Emissions in tons of CO2e in Amazon municipalities.

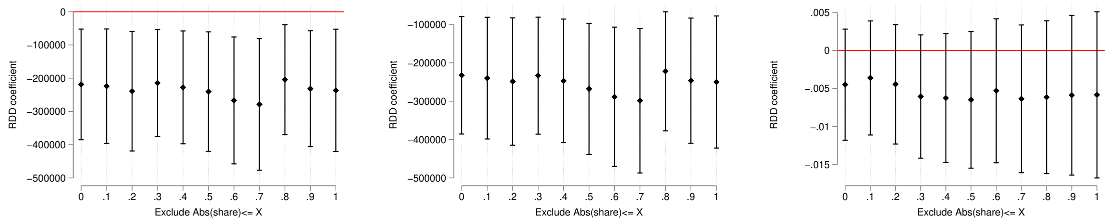


Notes: This figure shows the effect size, the β coefficient from estimating Equation 1 relative to the baseline and its 90% confidence interval using smoothed distributions. We smooth the distribution by replacing the value of the observations below or above a certain threshold with the value of that threshold. Thresholds are defined by the mean value of total emissions minus/plus its standard deviation scaled by factors ranging from 1 to 3. The red horizontal line shows the effect size from the preferred specification. The optimal bandwidth is constant across samples and is based on Calonico et al. (2014). Estimates are obtained using local linear estimators with a triangular kernel.

Figure A.7: Sensitivity to observations near the cutoff.

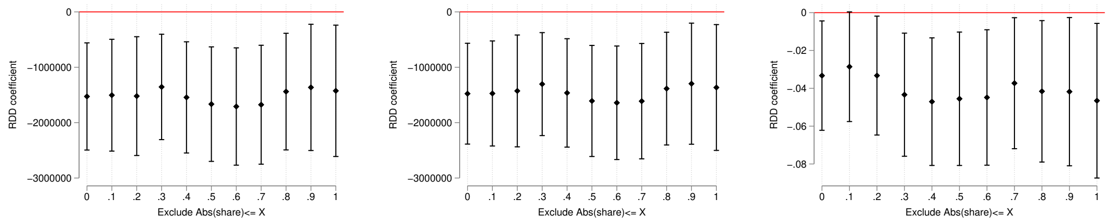
A. All municipalities with mixed-gender elections.

(a) Emissions in tons of CO2e (b) Emissions in tons of CO2e Land use (c) Deforestation as share of forest cover



B. Amazon municipalities.

(d) Emissions in tons of CO2e (e) Emissions in tons of CO2e Land use (f) Deforestation as share of forest cover



Notes: These figures show the β coefficient and its 90% confidence interval from estimating Equation 1 10 times, starting from no exclusions (the baseline case) and progressively excluding observations within 0.1%, 0.2%, 0.3%, up to 1% of the cutoff. Estimates are obtained using local linear estimators with a triangular kernel. The optimal bandwidth is based on Calonico et al. (2014).

Table A.3: Female mayor and emissions. Different kernel and polynomial order

	Total Emissions in tons of CO2e				Land Use Emissions in tons of CO2e			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Total								
Female mayor	-218,756**	-234,122**	-230,211**	-278,043**	-232,379**	-258,011**	-242,291**	-263,267**
	(101,193)	(112,829)	(110,210)	(121,037)	(93,063)	(102,760)	(102,288)	(108,029)
Mean outcome	291,668	262,323	339,591	285,693	172,653	181,222	217,123	160,848
Bandwidth	12.8	20.8	8.6	14.6	13.1	23.3	8.5	16.4
Observations	[1156, 1035]	[1644, 1304]	[830, 774]	[1296, 1113]	[1179, 1041]	[1742, 1373]	[826, 769]	[1411, 1185]
Panel B: Amazon region								
Female mayor	-1,527,424***	-1,199,905*	-1,547,957**	-1,148,758*	-1,477,081***	-1,103,449*	-1,476,340**	-1,090,148*
	(587,018)	(641,794)	(648,061)	(681,953)	(552,254)	(591,302)	(613,005)	(631,903)
Mean outcome	1,440,656	1,394,211	1,713,731	1,534,648	1,138,774	1,117,241	1,394,030	1,115,417
Bandwidth	13.0	14.3	8.9	9.9	13.4	13.6	8.9	12.0
Observations	[142, 125]	[154, 133]	[107, 99]	[122, 104]	[143, 125]	[147, 125]	[107, 99]	[135, 120]
Year & State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Order polynomial	1	2	1	2	1	2	1	2
Kernel	Triangular	Triangular	Uniform	Uniform	Triangular	Triangular	Uniform	Uniform

Notes: The dependent variable is the average annual emissions in tons of CO2e over the four-year term in all municipalities with mixed-gender elections (Panel A), the subsample of Amazon municipalities (Panel B). Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level in parentheses * p < 0.1, ** p < 0.05 and *** p < 0.01.

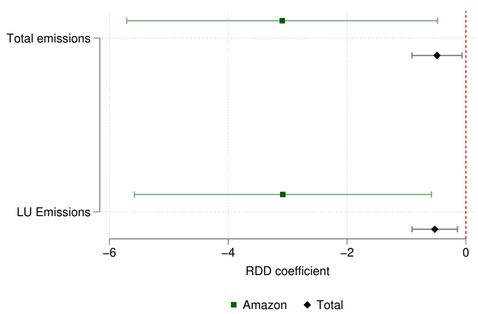
Table A.4: Female mayor and deforestation. Different kernel and polynomial order.

	Deforestation as a share of forest cover			
	(1)	(2)	(3)	(4)
Panel A: Total				
Female mayor	-0.004	-0.003	-0.006	-0.004
	(0.004)	(0.005)	(0.005)	(0.006)
Mean outcome	0.049	0.049	0.049	0.049
Bandwidth	11.8	17.0	8.0	14.3
Observations	[1054, 950]	[1407, 1172]	[761, 710]	[1243, 1064]
Panel B: Amazon region				
Female mayor	-0.033*	-0.030	-0.031*	-0.039*
	(0.018)	(0.020)	(0.017)	(0.022)
Mean outcome	0.104	0.103	0.104	0.104
Bandwidth	11.5	17.8	11.9	13.9
Observations	[130, 110]	[175, 151]	[131, 113]	[148, 125]
Year & State FE	Yes	Yes	Yes	Yes
Order polynomial	1	2	1	2
Kernel	Triangular	Triangular	Uniform	Uniform

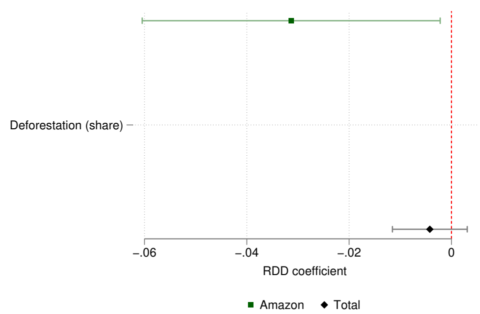
Notes: The dependent variables is deforestation as share of the baseline forest cover in each municipality over the four-year term. Panel A estimates equation 1 in the total sample and Panel B restricts the sample to Amazon biome municipalities. Estimates obtained using local linear estimators with a triangular kernel. Optimal bandwidth based on Calonico et al. (2014). Robust standard errors clustered at the municipal level in parentheses * p < 0.1, ** p < 0.05 and *** p < 0.01.

Figure A.8: Excluding municipalities in the LPM.

(a) Emissions in tons of CO2e



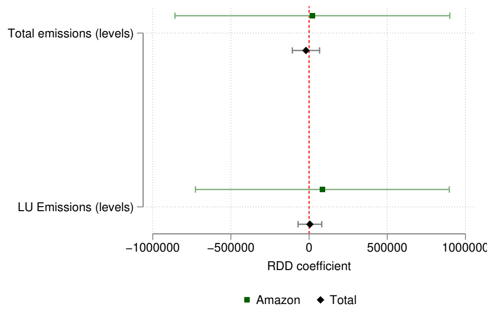
(b) Deforestation as a share of forest cover



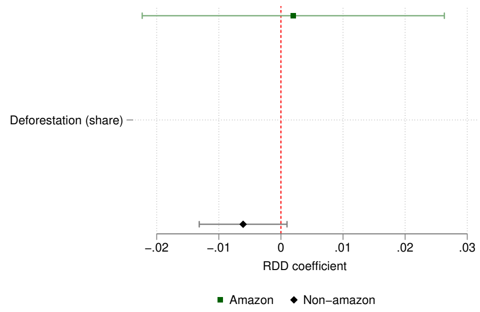
Notes: These figures show the β coefficient and its 90% confidence interval from estimating Equation 1 for all municipalities with mixed-gender elections and for the subsample of Amazon municipalities. The dependent variables are: the average annual emissions in tons of CO2e over the four-year term in all municipalities (Panel a) and deforestation as share of the baseline forest cover in each municipality over the four-year term (Panel b). Estimates obtained using local linear estimators with a triangular kernel and optimal bandwidth based on Calonico et al. (2014). All estimates account for state and round fixed effects.

Figure A.9: Differential skills between female and male mayors.

(a) College effect:
Emissions in tons of CO2e



(b) College effect:
Deforestation as share of forest cover



Notes: These figures show the β coefficient and its 90% confidence interval from estimating Equation 1, using mayor's education level (indicator of having college education) as treatment variable for all municipalities with mixed-gender elections and for the subsample of Amazon municipalities. The dependent variables are: the average annual emissions in tons of CO2e over the four-year term in all municipalities (Panel a) and deforestation as share of the baseline forest cover in each municipality over the four-year term (Panel b). Estimates obtained using local linear estimators with a triangular kernel and optimal bandwidth based on Calonico et al. (2014). All estimates account for state and round fixed effects.